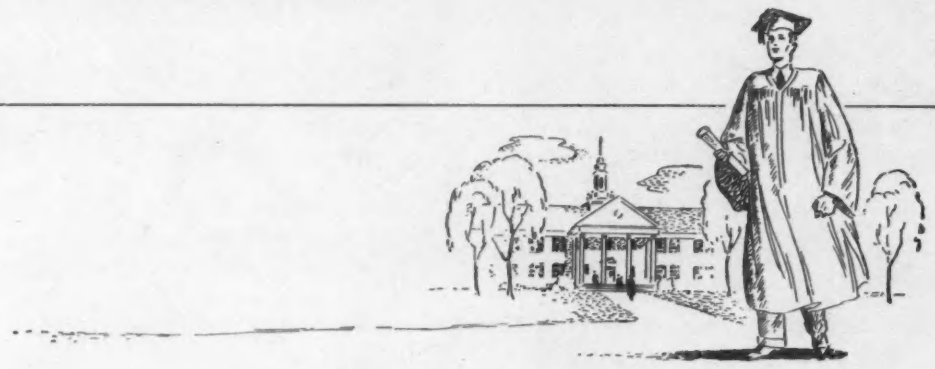
THE TECH ENGINEERING NEWS

Massachusetts Institute of Technology • 1938 • *May*

After Graduation . . .



WHEN you enter the practice of the profession of engineering you will, without a doubt, require a more detailed knowledge of the oxy-acetylene process of welding, cutting, and heat-treating of metals than you will carry away with you from college.

No matter where you locate, we invite you to consult Linde whenever you need assistance in problems involving the use of welding, cutting, flame hardening, flame softening, hard-facing or any other application of the oxy-acetylene process. There are 32 Linde offices in principal cities throughout the country.

Such assistance as this is made available to users of Linde products through the medium of Linde Process Service. The purpose of this service is to help consumers obtain the greatest possible value from every dollar spent for Linde oxygen—and everything else bought from Linde. Write or call the nearest Linde office for full information.

THE LINDE AIR PRODUCTS COMPANY

Unit of Union Carbide and Carbon Corporation

UCC

New York and Principal Cities
In Canada: Dominion Oxygen Company, Limited, Toronto

Everything for Oxy-Acetylene Welding and Cutting

LINDE OXYGEN • PREST-O-LITE ACETYLENE • OXWELD APPARATUS AND SUPPLIES FROM LINDE UNION CARBIDE

PRODUCTS OF UNITS OF UCC UNION CARBIDE AND CARBON CORPORATION

The words "Linde," "Prest-O-Lite," "Oxweld" and "Union" used herein are registered trade-marks.

OUR AUTHORS

WILLIAM M. MURRAY writes this month on photo-elasticity. Doctor Murray has been an instructor in the Department of Mechanical Engineering at the Institute since he obtained his Doctorate here in 1936. He did his undergraduate work at McGill University, from which he was graduated in 1932. His present field of interest is that of photo-elasticity and testing materials. He has previously been associated with the American Can Co. and with W. N. Best of Canada, where he was a junior engineer working on the installation of industrial oil-burning equipment.

M. F. JUDKINS is no doubt as well qualified to write on the sintered carbide process as any person, for he has been associated with the Firth-Sterling Steel Co. since the inception of the process. Born in Seattle, Washington, in 1906, Mr. Judkins received his B.S. degree in Chemical Engineering from the University of Washington in 1928. After a year as a research fellow in Metallurgy at the Carnegie Institute of Technology, he received his Master's degree in 1929. Mr. Judkins is now chief engineer of the Firthite division, and is chairman of the ASME special research committee on the cutting of metals.

JOHAM ADAM BERTSCH concludes his article on the four year plan in Germany. The first installment of this article appeared in the April issue of the TECH ENGINEERING NEWS. Doctor Bertsch has distinguished himself in chemical circles in this country by virtue of being the only American chemist chosen by the German government to investigate the causes of the *Hindenburg* disaster. Doctor Bertsch is now associated with the Monsanto Chemical Co. of St. Louis, Mo.

MANUEL S. VALLARTA, author of the article on cosmic rays in this issue, is an Associate Professor of Physics at the Institute.

PREVIEWS

WITH THIS ISSUE of the TECH ENGINEERING NEWS we conclude our activities until next fall. Several articles have already been proposed for publication at that time. Mr. Judkins will conclude his article on Firthite steel, which begins in this issue.

Among the other articles is one on biological engineering by John W. M. Bunker, who is Professor of Physiology and Biochemistry, and is in charge of Course VII-A at the Institute. Another article is now being written by the director of the Bureau of Standards on the subject of Standard Frequency Broadcasts.

By next fall, the new architectural building will be completed, and at that time we shall present Mr. E. A. Dockstader's article on the design and construction of the building. We also expect to present next term the article judged best among those submitted by students to our article contest which is now running. In addition, we will have our usual number of varied articles from prominent men in the engineering and scientific fields.

Physics
Chemistry
Mathematics
Thermodynamics
Applied Mechanics
Electrical Engineering
Entrance Physics and Mathematics

THE ASSOCIATED TUTORS

410 Memorial Drive, Cambridge

Kirkland 4990 A. L. M. Dingee, Director

EXPERT INSTRUCTION—EXPERIENCED TUTORS

BERKELEY PREPARATORY SCHOOL

(Established 1907)

An Accredited School

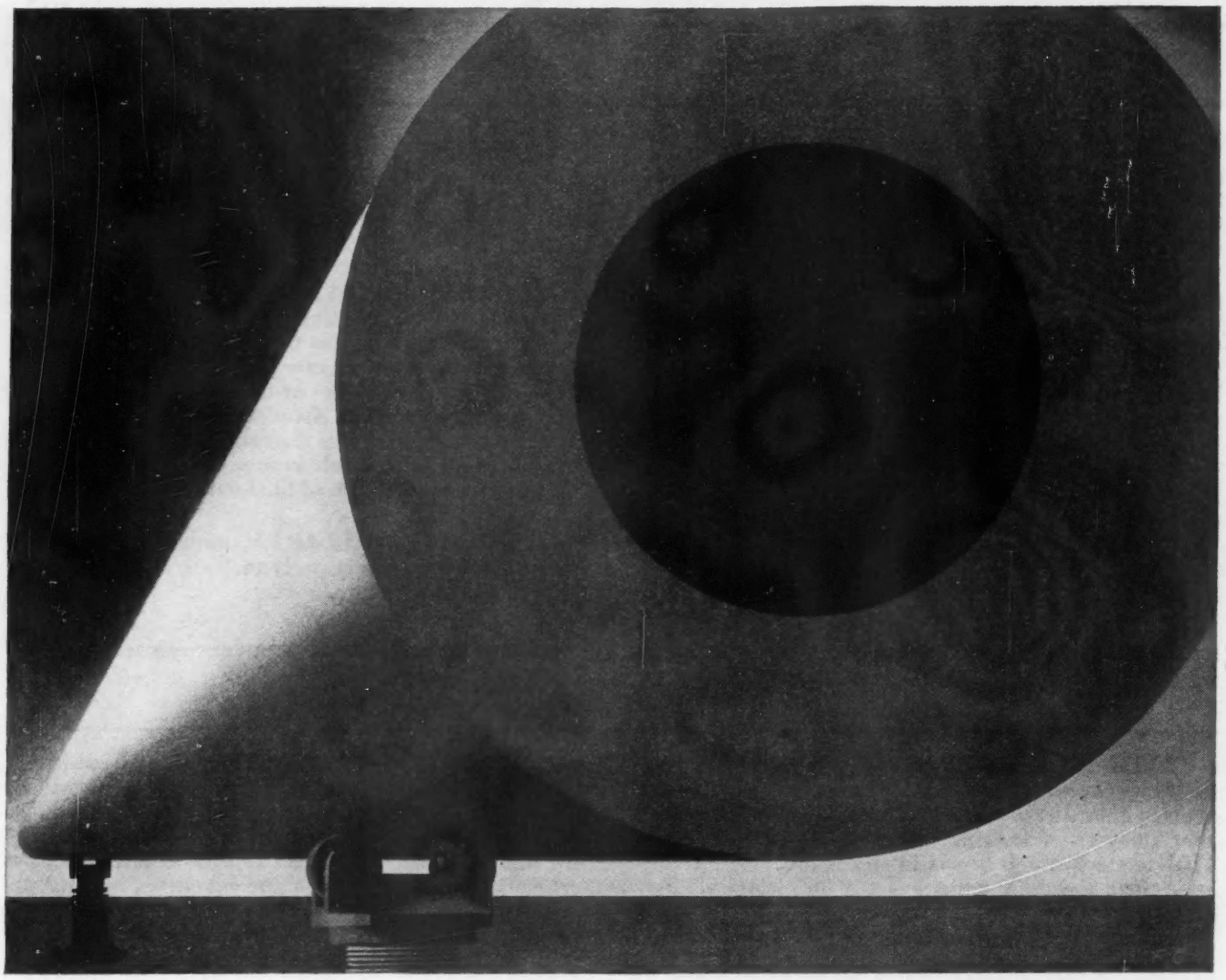
Preparation for all colleges and technical schools; entrance by certificate or examination

Day and Evening Sessions

SEND FOR CATALOG

HARRY F. CADE, JR. (M. I. T. '28) Headmaster

1089 BOYLSTON STREET, BOSTON Telephone Commonwealth 9262



HUGE—YET UNIFORM IN PHYSICAL PROPERTIES

NECESSITY hastens many a discovery. When deep drilling in the oil industry created the need of extra-heavy, extra-durable drill collars, their service requirements and economical construction presented some new machine-shop problems. Among them was the finding of a steel which could be heat treated in long, massive chunks (sometimes 8 tons and 40 to 50 feet long) to produce uniform high physical properties and yet be readily machinable.

Chrome-Molybdenum (SAE 4140) steel proved the solution. It is widely chosen for this purpose because: (a) It develops the requisite physical properties. (b) It responds well to heat treatment—hardening uniformly through the large sections involved. (c) Its machinability at the relatively high hardness is excellent. (d) It is not susceptible to temper brittleness. And —with all its unusual fabricating and service qualities, it is comparatively inexpensive.

Have you heavy-forging problems involving peculiar combinations of service and fabricating requirements? There's a Moly steel, most likely, that's exactly suitable. Investigate. Our free book, "Molybdenum in Steel," will prove helpful. Climax Molybdenum Company, 500 Fifth Avenue, New York City.

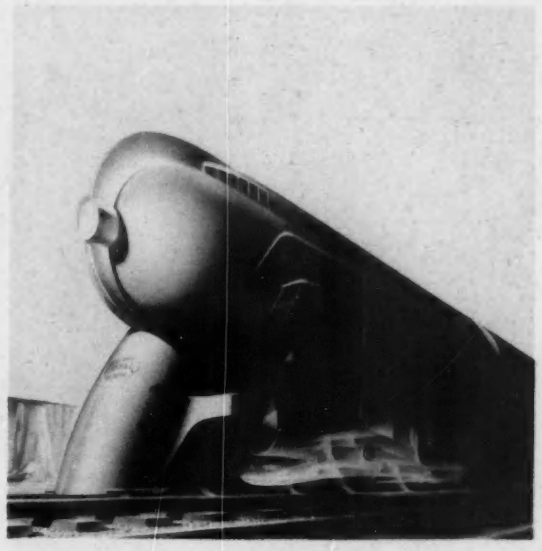
PRODUCERS OF FERRO-MOLYBDENUM, CALCIUM MOLYBDATE AND MOLYBDENUM TRIOXIDE

Climax Mo-lyb-den-um Company

MOLY

THE TECH ENGINEERING NEWS

PUBLISHED BY THE UNDERGRADUATES OF THE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY



VOLUME XIX NUMBER 4

CONTENTS FOR MAY, 1938

FRONTISPIECE: Moonlight and Rivets 80
POWDER METALLURGY, by M. F. Judkins 81
PHOTO-ELASTICITY, by William M. Murray 84
THE GERMAN FOUR YEAR PLAN, by Joham A. Bertsch 86
A NEWCOMER TO COSMIC PHYSICS: COSMIC RAYS, by Manuel S. Vallarta ... 88

Editorials

PREPARATION FOR MARRIAGE 90
MORE FIELD PRACTICE NEEDED 91
FOUR YEAR PLAN IN PRACTICE 91

Research in Review

COURSE XIX. PLASTICITY OF CLAY 92
COURSE X. HEAT RADIATION FROM GASES 92
COURSE VII. UPPER-AIR MICROBIOLOGY 93

Engineering Digest

ULTRACENTRIFUGE 94
CYLINDER MAINTENANCE 94
ARIZONA SUBWAY 95
FULL-FEATHERING PROPELLER 95

OUR COVER THIS MONTH

The cover for this month is from a photograph by Gerald Young.

Published monthly throughout the school year, at Walker Memorial, Cambridge A, Massachusetts, by the undergraduates of the Massachusetts Institute of Technology. Entered as second class matter, at the Post Office, June 1, 1920 at Boston, Mass., under the Act of March 3, 1879. Copyright 1938 by The Tech Engineering News.

Subscription per year $1.50. Foreign $1.75. Single copies 25 cents.

Moonlight and Rivets

Lockheed Photo by J. H. Washburn

Powder Metallurgy

● INDUSTRIAL USE AND DEVELOPMENT OF SINTERED CARBIDES

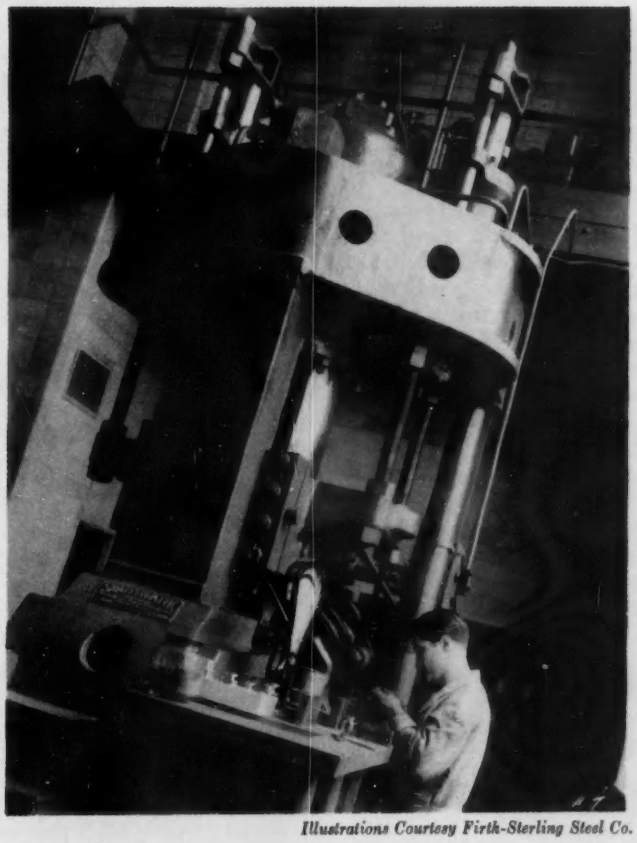
M. F. JUDKINS

MOST of the heavy metals unite with carbon to form carbides of outstanding hardness and resistance to abrasion. Of these hard carbides, that of tungsten is perhaps best known and, in many respects, the most interesting. Moissan, a French physicist and early experimenter, with the arc furnace first produced tungsten carbide in 1898. Carbon, produced by burning sugar in a graphite crucible, was mixed with tungsten metal and tungsten oxide. A chemical union between the tungsten and carbon was effected by subjecting the mixture to the full temperature of the electric arc. The extreme hardness of the product stimulated attempts to find a commercial use for it. Beyond laboratory investigations, undertaken to study the material and catalogue its properties, little was accomplished.

In 1904, Justian Honniman added to the fund of information on tungsten carbide through his investigation on the use of metallic tungsten for electric lamp filaments. In 1912, just prior to the World War, two Germans, employed by the Osram Lamp Company, situated just outside of Berlin, endeavored to substitute wire drawing dies made of tungsten carbide for the more costly diamond dies then in use. Heinrich Baumhauer, one of these men, conceived the idea of soaking the porous and rather spongy melted tungsten carbide with molten iron to fill the spaces and produce a workable die. This process is covered by United States Patent No. 1,512,191, October 21, 1924. Baumhauer's colleague, Karl Shroter, perfected the process similar to that in use today, which involves the pressing of finely pulverized tungsten carbide mixed with cobalt and nickel powders in molds, and the subsequent heating of the compacted material in hydrogen atmosphere to a temperature permitting bonding of the fine particles of tungsten carbide into a dense, nonporous material. This sintering process is covered by Patent No. 1,549,615, August 11, 1925.

Prof. Benno Strauss, Director of Research of the Krupp Works in Essen, to whom Shroter confided his serious difficulties in producing uniform tungsten carbide powders, undertook a research resulting in several patents on methods of producing tungsten carbide powders. The original German-made tungsten carbide was marketed under the trade name "Widia," from two German words, "*wie diamant*"— like a diamond.

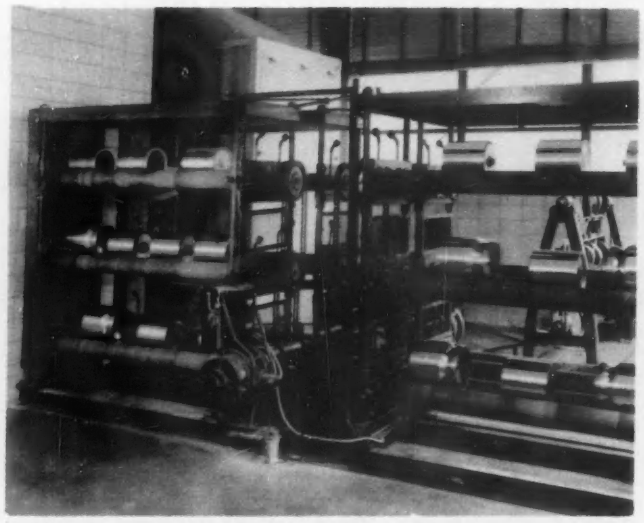
Sintered tungsten carbide has been termed the first product of the new art of powder metallurgy. In this limited sense, sintering is a method for producing metallic alloys from very fine and tightly pressed powdered metals without melting. The temperature need not exceed two-thirds the melting point of the lowest melting constituent. The mechanism of the sintering process is clearly understood when we consider that the metal powders are actually crystalline fragments. Heating this highly compressed crystalline debris above the recrystallization temperature permits growth of grains to restore the original crystalline shape characteristic of the metals, alloys and intermetallic compounds concerned. The intimacy of contact and thoroughness of mixing eliminate the necessity for any appreciable diffusion to produce a homogeneous alloy closely simulating the metallographic appearance of a cast structure. In general, sintered materials are free from dendritic segregation, ingotism, porosity, blowholes, fissures, and cold shorts. The crystalline grains are so exceedingly fine that the crystalline structure approaches the amorphous condition. Sintered materials, in consequence, escape directional weaknesses, characteristic of melted and cast materials.



Illustrations Courtesy Firth-Sterling Steel Co.

400-ton bilateral compacting press. Dust-free atmosphere through electrostatic precipitation

Sintering has many distinct advantages over melting and casting. Because neither a protective slag nor deoxidation additives are necessary, metals and alloys of exceptional purity can be produced. Mutually insoluble and even immiscible metals, as well as metals of greatly differing specific gravities and widely separated melting points, can be readily mixed and alloyed by sintering methods. Metals and non-metals can be readily combined, as in the case of tungsten and carbon. The composition of alloys need not be limited by solubility or miscibility, as in the case of castings. Parts may be pressed to shape, requiring little or no machining or grinding. The grain size of sintered materials is largely dependent upon the grain size of the original powders and upon the sintering treatment, that is, time and temperature of heat



Rolling races on which ball milling is done

treatment. As an obvious consequence, final grain size can be controlled within almost any desired limit. The methods of powder metallurgy, then, are seen to permit the metallurgist more latitude in the preparation of metals and alloys, a higher degree of purity and more precise control of production and desired properties in the final product than could ever be the case with melting and casting methods.

A few specific examples of modern products made possible only by sintering will help to understand the truly unique and superior qualities of powder metallurgy. Efficient bearings must be so designed that lubricants will be retained or supplied for the surfaces in frictional contact. In older types of bearings this was accomplished by means of oil grooves. The majority of automotive bearings, other than anti-friction ball and roller bearings, are today made by sintering methods from copper powder and graphite, which in itself is a lubricant. These modern bearings are made with a high degree of porosity to retain oil. The pores are uniform in size and regularly distributed throughout the bearing. This is accomplished by mixing with the powders a predetermined quantity of volatile salts which pass off during sintering, leaving the required number, size, and distribution of pores in the finished product.

Silver is known to be the best electrical conductor but has an unfortunate tendency to be consumed by arcing when used as contact points for making and breaking electrical circuits, as in telephone and telegraph transmissions. Highly efficient silver-carbon contacts are made by sintering methods.

Alnico, the new hyper-magnetic alloy consisting of aluminum, nickel, cobalt, and iron, is unfortunately very difficult to cast and forge and practically non-machinable. The shapes of electro-magnets to be made from this material are not simple, but, on the contrary, are quite involved. These difficulties are easily overcome by applying the methods of sintering.

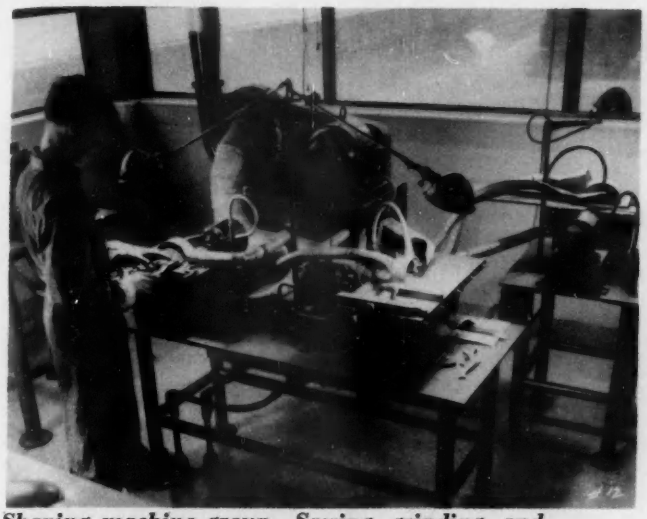
With the growing popularity of welding methods in construction of all types, ranging from jigs and fixtures for use in machine shops to heavy machine tools and presses and extending to building construction and bridges, special welding rod materials are necessary. Such long cylindrical pieces are easily manufactured by the methods of powder metallurgy by mixing with the powdered ingredients a suitable proportion of an organic plasticizer which will permit extrusion of the required sizes and shapes of rods, followed by a sintering process during which the plasticizer volatilizes and passes off as vapor.

Powder preparation — Carrara glass walls — Stainless filter stand

New plant where Firthite and Firthalloy are manufactured

Metallic tantalum finds wide use in modern manufacturing and materials. Tantalum is used in sheet, rod, and wire form in vacuum tubes where its high melting point, low vapor pressure, and scatter characteristics are highly desirable. Thin sheets of pure tantalum metal are used in heat interchangers because of the material's exceptionally high thermal conductivity. Spinning jets for rayon, which is highly corrosive because of the sulphuric acid content, are made from tantalum sheets, as are certain special types of electrolytic condensers. All ductile tantalum made today is produced by the methods of powder metallurgy. When so produced, tantalum can be rolled, drawn, spun, and swaged at room temperature.

Sintered carbides are today manufactured in many forms including, not only tungsten carbide, but tantalum and titanium carbides as well. These materials are widely used as tips for cutting tools, for wire drawing dies, and for other wear-resistant applications such as grinder rests, gage anvils, guides for thread and wire and related applications where resistance to abrasive wear and chemical, corrosive attack are of paramount necessity. In order to properly appreciate the nature and properties of these unique materials, the manufac-



Shaping machine group. Sawing, grinding, and sizing pre-sintered Firthite blanks

turing process used in the production of sintered tungsten carbide is described in detail. The manufacture of Firthite by the Firth-Sterling Steel Company of McKeesport, Pennsylvania, begins with the mining of Ferberite (iron tungstate) ore at their mine in Nederland, Colorado. The concentrate is shipped to the mill in Pennsylvania, where it passes through a chemical refinement process resulting in tungsten metal powder of remarkable purity and extreme fineness. The metal powder does not contain more than 0.01 of one per cent impurity and the fineness is at least 225 mesh. The tungsten metal powder is thoroughly mixed with about six per cent by weight of carbon in the form of lampblack by ball milling in stainless steel rolling barrels charged with stainless steel balls and comminution is continued until, despite the wide disparity in specific gravity, the components of the mixture cannot be separated by shaking. Combustion carbon-determination samples selected at random from the mixture must check within 0.02 of one per cent. The mixture of tungsten and carbon is carburized in tightly stoppered graphite bottles in an electrically heated, hydrogen filled furnace. Carburization is controlled so that the product is the chemical individual tungsten mono-carbide with the formula WC. Control is exercised to prevent both a deficiency in carbon, which would result in tungsten sub-carbide, W_2C, and free carbon in excess of the proportions required by the formula WC for the mono-carbide. The tungsten carbide is returned to the ball mill. For the general-purpose grade, about six per cent by weight of purified cobalt powder is added. This proportion of cobalt is varied from three to 25 per cent to produce different grades with physical properties suited to each type of use. The mill is filled with distilled water. Ball milling is continued until each minute grain of tungsten carbide has been coated with an envelope of the malleable cobalt. The water is removed by filtration, followed by drying in vacuum ovens. The dried pellicles of tungsten carbide and cobalt are passed through a 325 mesh screen and stoked through a hydrogen furnace to reduce any oxide films developed during ball milling. Because the powder is so extremely fine and abrasive, it will not flow readily in a mold. It is, therefore, necessary to add a lubricant which, being completely volatile, passes off in its entirety during the first stages of sintering. After blending the powder with the lubricant, the mixture is pressed in steel dies in a hydraulic press at from 4,000 to 60,000 pounds per square inch of projected area. The bulk volume of the powder is three times the volume after pressing. Because the compact is so highly condensed during pressing, it is necessary to employ a die which can be completely disassembled. This in turn necessitates the use of a bilateral press. The horizontal ram is used to support the sides of the die while the vertical ram descends on the plunger which compacts the powder.

The pressed billet, which has no more strength than a pharmaceutical pill, is placed in a shallow graphite boat and stoked through an electric furnace against a metered flow of hydrogen. This preliminary heat treatment confers sufficient strength upon the billet to withstand the operations of sawing, grinding, shaping, and sizing. All forming and sizing operations on this half or pre-sintered material must take into account an approximate shrinkage in all linear dimensions of about 20 per cent during the final heat treatment or sintering, which is performed in electrically heated, hydrogen filled furnaces at a temperature in the neighborhood of 3000 degrees Fahrenheit. The walls of the shaping room are of Carrara glass to facilitate the maintenance of absolute cleanliness. Any dust or other contamination would burn out of the product during final sintering, leaving objectionable porosity. In the shaping room, each group of machines is interlocked with an individual Rotoclone which effectively disposes of the dust created during shaping and sawing. In the half-sintered condition, the material can be chucked or held in a collet of a speed lathe and turned, faced, bored, and even threaded, using a diamond chip held in long-nosed pincers extending through the tool post of the lathe. The final sintering temperature varies, depending upon the physical properties desired in the final product and upon the percentage of cobalt binder which is used.

It is probable that the cobalt does not really melt during final sintering. The shaped half-sintered pieces are packed in carbon boats in powdered graphite to prevent surface decarburization by the hydrogen furnace atmosphere and on removal from the furnace after completion of the final heat treatment the corners of the blanks are found to be as sharp as when the material entered the furnace. Even incipient fusion would of course cause rounding of edges due to surface tension if a liquid phase appeared at any time during sintering. It is known, however, that at the solicus temperature at equilibrium, cobalt dissolves at least 15 per cent tungsten carbide. Although these conditions may not obtain in commercial sintering practice, it is likely that appreciable quantities of tungsten

(*Continued on page 100*)

Front view of bank of final sintering furnaces— Temperature being checked with optical pyrometer

Photo-Elasticity

• A SIMPLIFIED MEANS FOR SOLVING STRUCTURAL STRESS PROBLEMS

WILLIAM M. MURRAY

ONE of the problems which is continually presenting itself to engineers is the determination of stress distribution in structures and their parts. Since these may vary in size from a tiny piece of an automatic machine to a huge building or bridge, and possess any one of an infinite number of geometrical forms, the problem in many cases is a difficult and complicated one requiring very ingenious methods of solution. To the mathematicians must go credit and appreciation for their work in producing many solutions. However, mathematical reasoning alone cannot be expected to cover all conditions, and other methods must be used too. Very frequently tests upon models, either full size or in some reduced scale, have yielded results which have enabled the engineer to reach the desired goal. One must, of course, bear in mind the fact that no one method of stress determination may be particularly satisfactory in all cases, and that the skill and judgment of the engineer will play a most important part in the future.

A useful application of model testing to stress analysis is to be found in the photo-elastic method which has recently been receiving a good deal of attention both in this country and in Europe. The possibility of this method was first recognized a little over one hundred years ago by Brewster, who observed that stressed glass showed brilliant colors when viewed through a polariscope. At that time, very little attention seems to have been paid to the practical application of the discovery, as it was not until about seventy-five years later that engineers began to make use of it as an instrument of applied science. In the last fifteen years, however, photo-elasticity has made very rapid progress, especially in this country where monochromatic light and highly sensitive materials have been generally adopted.

The basic requirement in a photo-elastic material is that it should become temporarily doubly refracting when under stress; in addition, it should possess high transparency, high optical activity to stress, and good machinability. The last named property is of equal importance to the others, since, otherwise, the cost of making up models may be prohibitive. Needless to say, all the most desirable properties are not to be found in any one material, and a compromise must be made, depending upon the particular purpose for which a model is required. Glass, the original material, possesses high transparency, high elastic properties, and freedom from deterioration with time, but is difficult to machine and has such a low stress optical coefficient, that the use of monochromatic light is almost impossible. The introduction of celluloid was a great advance, both for its higher optical sensitivity and its ability to be easily machined. More recently, a number of synthetic plastics have appeared as suitable materials, and of these, Bakelite, which is used extensively in this country, has perhaps the most advantageous and least disadvantageous properties. All the synthetic materials, however, suffer from the serious disadvantage of deteriorating with time through the development of residual stresses along the boundaries. These edge stresses can, in many cases, be relieved by proper heat treatment, or can be removed entirely by machining. The following table shows the relative optical sensitivity of a few of the photo-elastic materials.

Glass	1.0
Celluloid	4.1
Bakelite	16.5
Phenolite	21.0

There are a number of other materials available, but most of them possess the serious disadvantages of high creep or low elastic properties when the optical sensitivity is high enough to compare with Bakelite or Phenolite.

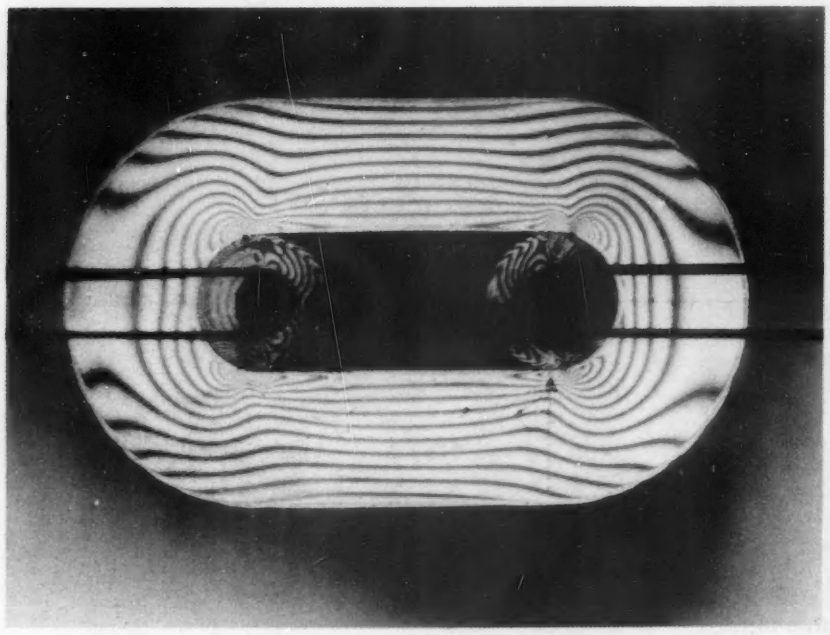


Figure 1

If a thin body like a plate or a narrow beam is loaded in such a manner that the forces acting upon it are confined to its own plane, then there exists what is known as a condition of plane stress, or a two-dimensional stress distribution. In practice, there are many problems involving plane stress, and a great many three-dimensional problems which can be simplified to two dimensions. To all of these the photo-elastic analysis is particularly well suited and provides a rapid means of stress determination, especially when the outline of the model assumes a complicated form.

If a beam of plane polarized light is directed upon a stressed model whose plane is perpendicular to the direction of the light propagation, the light, on striking the model, is repolarized in the direction of the principal stresses, and passes through the material along the principal

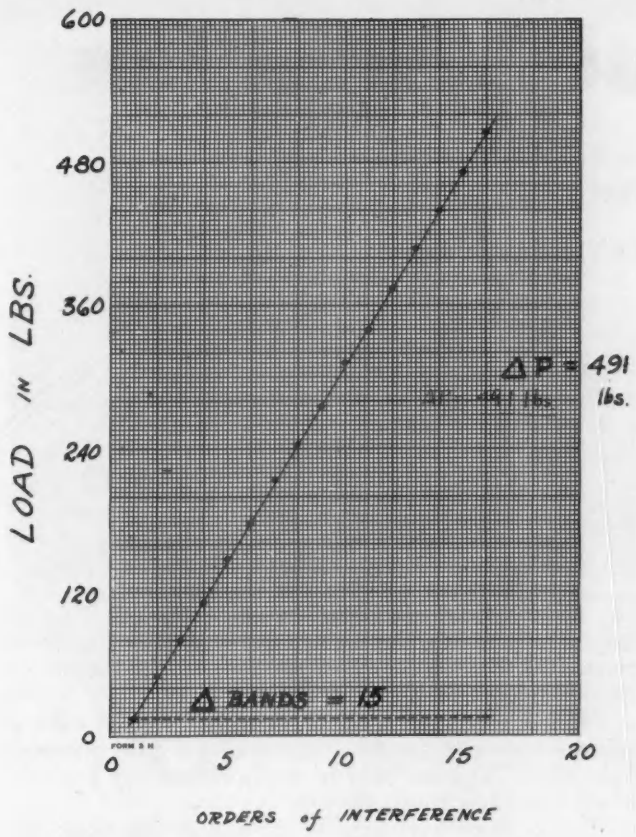


Figure 2. Calibration Curve for Bakelite

planes of stress. If at any point the two principal stresses are different, the material exhibits different optical properties in their two directions, with the result that the two components of the original light waves will have different velocities while passing through the specimen, and on emerging from the other side will be found in planes at right angles and out of phase. By experiment, it is found that the difference between the velocities of the two component waves of light in the model is proportional to the difference between the principal stresses. The difference between the velocities is also very closely proportional to the phase difference of the two waves of light as they leave the stressed material, and therefore, by measuring this phase difference, one is able to obtain a measure of the difference between the principal stresses. By introducing a polarizing device, known as the analyzer, behind the model and orienting it so that its plane of polarization is either parallel or perpendicular to the plane of the polarization of the original beam of light, the two waves emerging from the model in planes at right angles can be made to interfere in a single plane. When white light is used, the image of the model will show one or more series of bright colored bands corresponding to each particular wave length of light, and gradually merging from one color into the rest; monochromatic light produces alternate light and dark bands as shown in Figure 1, which represents a stressed model of a chain link. Each one of these dark bands is known as an isochromatic line, and at all points on one of them, there is a constant difference between the principal stresses. This is a very valuable result, since it provides a direct means of determining the free boundary stresses, which in many cases are the most serious. At any point along a boundary, one of the principal forces is zero, and hence, the difference, obtained from the photo-elastic picture, is equal to the other one.

The question of determining the values which should be assigned to the isochromatic lines now arises; and fortunately this can be answered by a calibration of the material with a small tensile test specimen. In the case of direct tension, there is no lateral stress, and the direct stress (load divided by area) is equal to the difference between the principal stresses. As load is applied to the test specimen viewed in monochromatic light, the whole will alternately turn from dark to light a number of times, depending upon the magnitude of the applied load. Every time a complete cycle of the change has been completed there is a change of one order of interference, which is equivalent to the change from one isochromatic line to the next. From the observations of a tensile test, a plot of load against orders of interference can be made, and the change in load corresponding to one order of interference can be found. Figure 2 shows such a plot for bakelite, which gives a straight line relationship between the load and orders of interference.

In order to determine the factor (fringe constant) to apply to the isochromatic line in a model for finding the stress, one should refer the load on the tensile specimen to the area of cross section. To take care of different thicknesses in the direction of the path of light, the orders of interference should be referred to unit thickness of material. As an example, Figure 2 shows a change in load of 491 pounds corresponding to a change of fifteen orders of interference in mercury green (monochromatic) light.

$\Delta P = 491$ pounds = change in load.

Δ bands = 15 = change in order of interference.

$h = 0.382$ inch = thickness of specimen in the direction of the path of the light.

$b = 0.374$ inch = width of specimen perpendicular to the path of the light.

$$\text{Fringe constant} = \frac{\text{change in stress}}{\text{change in orders of interference per unit thickness}}$$

(*Continued on page 97*)

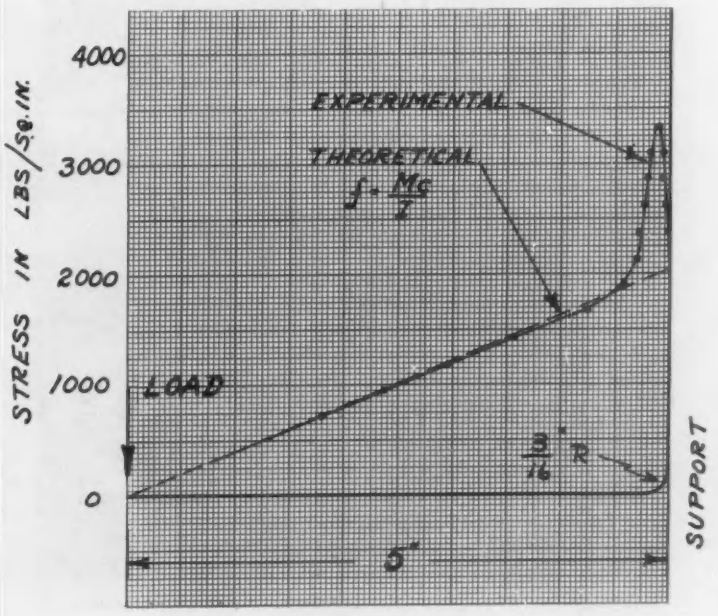


Figure 3. Stress Along Edge of Cantilever Beam

The German Four Year Plan

• INDUSTRIAL AND ECONOMIC FREEDOM PLANNED FOR THE "NEW" GERMANY

JOHAM A. BERTSCH

This is the last section of a lecture which has been delivered many times by Doctor Bertsch. The first part was printed in the "Tech Engineering News" for April, 1938.

ONE of the greatest problems for Germany is the fat supply. Germany consumes about two million tons of edible fats annually and has to import about one million tons. Besides, two and a half million tons of press-cakes from oil seeds are normally consumed as fodder. Every effort is made to raise the domestic production, and the area for planting rape, flax, and hemp has been increased from 10,000 hectares in 1933 to 104,000 hectares in 1936, and will again be raised to 120,000 hectares for production of 83,000 tons oils and valuable fiber for textiles, and to eliminate the importation of jute from tropical countries. Every farmer has planted a small area of his land with hemp or flax and donates the yield to the newly created army. They cannot step beyond that area without taking away too much area from other vital agricultural products. You see, they simply do not have enough area to produce sufficient food.

The industrial supply of fats, about 100,000 tons for soap and glycerol, is practically all covered by chemical synthesis. High molecular hydrocarbons which are produced in the Fischer-Tropsch Process are oxidized under pressure to fatty acids. The fatty acids with soda ash form the soap. Glycerol, formerly made from fats, is produced by fermentation of sugar, the sugar being made from waste lumber (*Industrial Engineering Chemistry, News Edition, 1937*, page 150).

Courtesy Colorado Fuel and Iron Co.

The soya bean cultivation is not yet fully developed, but is being pushed strongly ahead.

Up to this time whaling was the monopoly of Norway and England, and Germany had to import 250,000 tons of whale oil. Now a new whaling fleet has been created and in 1937–1938 they expect a production of 100,000 tons of whale oil as a start.

Margarin is preserved for many months in a very ingenious manner by the addition of a pepsin preparation called "Nigiton," which simply digests any bacteria which otherwise would destroy the fat.

You have perhaps read in the papers that they collect carefully any waste of food and use it for feeding hogs. Bones are collected by boys and girls to be used for glue and phosphate fertilizer. It is not so much the actual tonnage of such products which is gathered here, but the spirit which is created in the young people; namely, that they have to help the nation, that they should be thrifty even in little things, and that waste must be combated.

The importation of raw materials for textiles, cotton and wool, required, up to 1934, about 35 per cent of the value of Germany's imports. Germany was the largest importer of United States cotton. The Four Year Plan changed this rapidly and the hostile attitude of the American press and the various boycott movements accelerated the process of elimination of imported cotton and wool and their replacement by domestic products; namely, synthetic fiber from cellulose which is obtained from wood.

The fiber itself is basically nothing new. There are three main types of synthetic fiber existing for textiles:

1. Viscose cellulose fiber.
2. Ammonia copper cellulose fiber.
3. Acetalicellulose fiber.

The viscose fiber represents about 90 per cent of the present synthetic fiber production.

I cannot go into details about the chemistry and history of the fiber here. I merely want to say that viscose is made from cellulose of birch trees and pine trees, treating the cellulose with caustic soda to make alkalicellulose. Alkalicellulose is transformed to cellulose xanthogenate with carbon bisulfide. Xanthogenate is soluble in alkali and represents a fluid of honey-like viscosity. This viscose is pumped under pressure through fine openings of 0.08 millimeter, openings arranged like the spinnaret of a spider, and the bundle of extremely thin fibers produced is passed through a bath of H_2SO_4 and Na_2SO_4 where the cellulose is regenerated in the shape of long threads. This long fiber, if used uncut, represents artificial silk. In order to make it more fluffy, to introduce more air into the texture

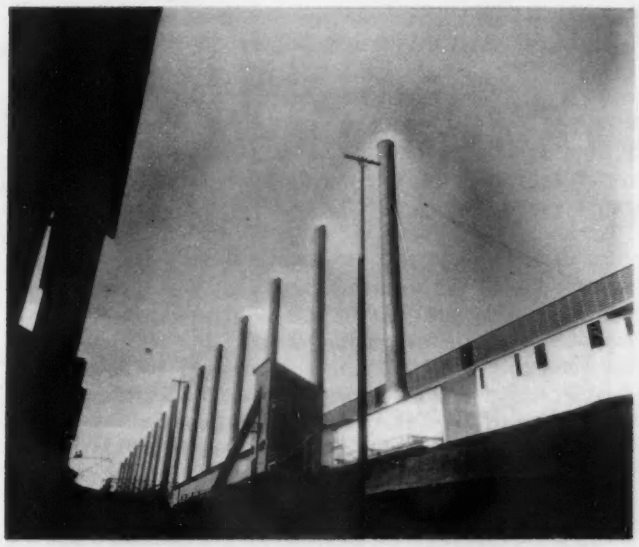


Photo by Eugene Hutchinson

and to make it a warmer material it is cut to so-called staples, i.e., threads of a few inches length which are curled by a special step in the process by steaming and quick cooling. This cut and curled staple fiber is the German cellwool, Vistra, Woolstra and other brands. It was a tremendous task to adjust the physical properties of this Vistra to the spinning machinery for cotton and wool goods. But finally a thousand difficulties have been overcome and today the cellwool industry operates with a capital investment of three and a half billion marks.

In 1933 the production of cellwool in Germany was 3.3 million kg.

In 1934 the production of cellwool in Germany was 8 million kg.

In 1936 the production of cellwool in Germany was 43 million kg.

In 1937–1938 the production of cellwool in Germany is expected to reach 75 million kg.

At present the Germans are experimenting with synthetic wool. One process liquefies old wool by a solvent and spins new fibers similar to the viscose process. Other processes are making synthetic wool-like substances from casein and from fish albumin. The nitrogen content of the wool seems to be important for its properties, so nature is imitated by using raw materials containing nitrogen, like casein and albumin.

An important process was introduced in the newly revived flax industry. To separate fiber from the surrounding cell structure, a fermentation process was used which required weeks of time and much handwork. A recent development, called the Geiss process, uses a chemical-mechanical process which takes about two hours for the job which formerly required several weeks. This new fiber has a tensile strength of 57 km. as against 22 for United States cotton, 30 for German hemp, 14 for 1935 viscose, and 18–25 for 1936 viscose. Flax grows even on a low-grade soil and Germany intends to convert 500,000 to 700,000 hectares of unused unfertile land for the production of flax.

Thus each of these new industries has brought men back to work, permanent work, too, as the government protects the new industries, making outside competition with cheaper raw materials impossible. Even if the domestic goods from domestic raw materials are somewhat higher in price than if they would be made from cheaper imported raw materials it does not mean very much, as it is much more important to have men back to work instead of having them on the dole list.

The organization of this vast research program, going on on a nation-wide scale, is a German masterpiece. The subject of research is easily determined by the list of importations which statistically has been maintained over a period of years with a high degree of exactness. The executives simply have to state how many of the imports have to be substituted by domestic products. All the services, equipment, and talent in the country are placed at the disposal of the national welfare. A nation-wide appeal was issued, the highly effective propaganda machine went into action, and the solution of the problem is now a matter of national honor.

All individuals competent to assist are classified and assigned to the activity in which they can render the greatest service. All positions under the German Ministry of Education that have to deal with applied research are unified. A research council plans all these various investigations. The number of research organizations now within the jurisdiction of the Reich Research Council is about a thousand.

Germany is the paradise of the engineer at present. The importance of engineering work for the welfare of a nation is plainly evident. The engineer is trying to clear the chaos which was created by the politicians of the past.

In closing, I wish to state that the general price policy of the German Reich is neither deflation nor inflation. The vicious cycle of raising wages, raising prices, raising wages, and raising prices is not considered as sound as stability of wages and prices. The latter is considered important, as it allows industry to calculate for the future.

The general standard of living will be raised very slowly only to the extent that the national wealth allows. They do not burden future generations in order to live more comfortably. Disputes between industry and labor are eliminated by compulsory arbitration. Strikes are considered a crime against the nation's welfare. Germany cannot afford losses by strikes. Most of the professional trouble makers in the field of labor are outside of the country in France and the United States, where they continue their old game successfully, as you well know yourself. The industrial worker enjoys a high-grade protection by the government, more than many small business men get.

In general I wish to say that for reliable information we should look at the engineering progress and the production figures in Germany. These give us a clearer

(*Continued on page 98*)

Photo by F. S. Lincoln

A Newcomer to Cosmic Physics: Cosmic Rays

MANUEL S. VALLARTA

HOW did we gather our vast fund of information about the universe in which we live? A decade ago the answer to this query would have been brief and precise: except for rather meager news conveyed by meteorites, by far the greatest part of our present knowledge has been transmitted to us in the form of light waves. Captured by the telescope and later made to yield their secrets through the mild blandishments of the spectroscope, they have given a formidable store of information about the size, distance, composition, motions and even the past history of celestial objects around us, thus enabling us to construct a magnificent picture of the entire universe. The discovery of cosmic rays, tiny charged particles of gigantic energy and mysterious, though surely extra-terrestrial, origin, has added a third and possibly very important element to our sources of observational knowledge.

The discovery of cosmic rays is an amazing instance of a fundamental physical fact found as a consequence of the pitiless tracking down of an apparently irrelevant and unimportant phenomenon. Ever since the days of Coulomb it has been known that a gold-leaf electroscope electrically charged and left to itself would in the course of time lose its charge. It was then generally believed that the reason for this lay in imperfect insulation of the support of the gold leaf, but efforts made over a long period of time to provide better insulation, using all the resources of a rapidly developing electrical science, failed to secure the desired result: nothing apparently could be done to stop the slow but sure trickle of the electric charge. The discovery of gaseous ionization and of radioactive disintegration gave the first clue of the underlying process: what was really happening, physicists of the early years of our century reasoned out, was that the earth's crust and the ground contain a tiny amount of radioactive material, whose products of disintegration ionize and turn the air between the gold leafs into a temporary electrical conductor, through which charge leaks out. With improved knowledge of the nature and properties of the products of a radioactive disintegration, this simple explanation could soon be put to a crucial test. If an electroscope, or better still an ionization chamber, were surrounded with a lead shield as an absorbing material, all ionizing particles produced by radioactive disintegration should be absorbed therein, and therefore the electroscope should remain charged. But when the experiment was carried out, it was found, to the great surprise of the physicists performing it, that the discharge took place precisely as if the lead shield were not there. MacLennan and Burton, who carefully and painstakingly performed this experiment, thus felt they must conclude that if the observed phenomenon was due to ionizing particles produced by radioactive disintegration, they must be very much more penetrating than those that had been previously recognized and studied in the laboratory.

A still more startling piece of evidence was unearthed by Wulf. He reasoned that if the explanation suggested above were true, then an electroscope taken high above the ground should discharge more slowly than one placed at ground level, because then some of the radiation emitted at the ground would have to be absorbed by the intervening air layer. He then proceeded to measure the discharge rate at street level in Paris, and then on top of the Eiffel Tower. Again he was startled to find that his electrometer was measuring just about the same discharge rate at this point of vantage, a thousand feet above the Seine, as at street level. As a consequence of this experiment, the literature of the period is full of suggestions as to "radioactive contamination" of the atmosphere. It remained for Gockel to drive Wulf's experiment to its logical conclusion. Why not place the instrument on a balloon, and thus make certain whether the discharge rate (intensity of the ionization current) changes or not with altitude? He carried out the experiment with great haste himself, but possibly because of this or of unsatisfactory apparatus his results were inconclusive. They had, however, the merit of attracting widespread attention to the problem, and it was not long before Hess first, and Kolhörster next, proved by experiments made on a balloon that, far from decreasing, the ionization current increased rapidly with altitude. Hess interpreted this fact as being due to a radiation coming from above, an achievement for which he was awarded the Nobel Prize in Physics two years ago. When Millikan then showed that this ionization current persisted after the apparatus had been sunk to a depth of ten to twenty meters of mountain-lake water, free from radioactive contamination, the existence of a very penetrating radiation, of energy very much higher than the energy resulting

Wilson cloud chamber showing multiplication of cosmic-ray ionizing particles in their passage through lead
Photograph by Lewis Fussel, Jr., Harvard University

from radioactive disintegrations, was generally recognized, and the name "cosmic rays" came into use to indicate their extraterrestrial origin.

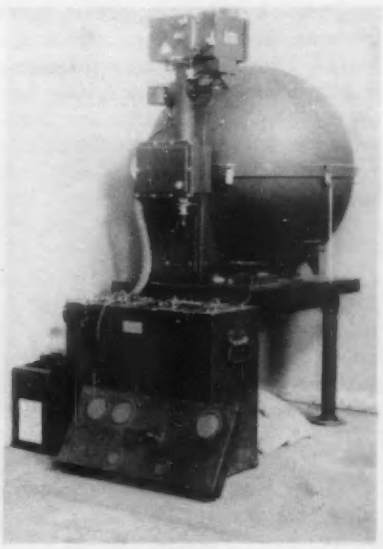
The problem of cosmic radiation may be divided into two parts: that which has to do with primary rays, i.e., those which already exist outside the atmosphere; and that which is concerned with secondary rays, which come into being as the high energy primary wrecks the atomic nuclei with which it collides as it passes through the atmosphere and which, together with their progeny of tertiaries, etc., is then detected by our measuring apparatus. Some very interesting new particles have been discovered among secondary cosmic rays, as the positive electron, or positron, foreseen by Dirac and discovered by Anderson, a discovery for which he was awarded the Nobel Prize in Physics three years ago. More recently Anderson and Neddermeyer in Pasadena, and Street and Stevenson at Harvard have found a particle of mass intermediate between that of the electron and proton, and charge of magnitude equal to that of either, but the evidence is as yet under scrutiny. In spite of the great interest of secondary particles and their theoretical interpretation, for which the physicist finds himself pitched headlong into the very heart of relativistic quantum theory and its apparently insoluble puzzles, we shall not dwell on phenomena due to secondaries but, in line with our program of dealing with cosmic rays as a problem in cosmic physics, focus our attention on the question of the nature, origin, and properties of the primaries.

One disturbing point which the thoughtful reader may already have in mind will be discussed at the outset. If primaries play general havoc with atoms on their passage through the atmosphere may it not be that practically all the particles we detect on our instruments are secondaries? If so, how do we know anything about the primaries? The answer is that although it is true that probably all the particles that reach any point in the atmosphere, except perhaps the higher layers of the stratosphere, are secondaries of ill-defined intensity, happily a good fraction of the latter have the property of conserving the *direction* of their progenitors.

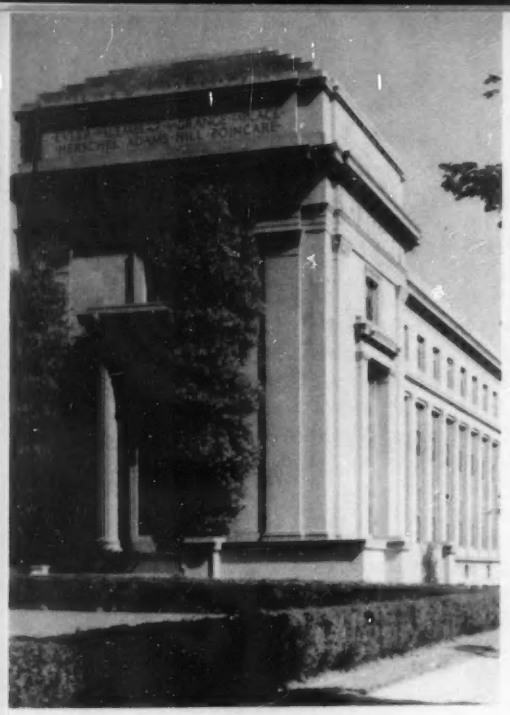
To detect and measure cosmic rays, three different kinds of apparatus are used: the ionization chamber, the Geiger-Müller counter and the Wilson cloud chamber. The first is best suited for measurements of total intensity (number of particles per second) of cosmic rays, and consists essentially of an insulated rod or wire inserted in a bomb or container in which gas (usually an inert gas like argon) is kept, ordinarily at high pressure. An electric charge is transferred to the rod, and thus a difference of potential is established between it and the bomb's walls. If now a particle capable of ionizing the gas traverses the container, part of the charge will be conducted by the ions away from the rod and onto the walls. This "ionization current" depends on the number of ions and therefore on the number of ionizing particles; hence, if the latter are cosmic rays the ionization current is a measure of their intensity. The second may be used as further described below to measure the intensity of cosmic rays coming from chosen directions. It consists of a glass tube full of gas (such as hydrogen, nitrogen, etc.) at reduced pressure; around the inner surface of the tube is wrapped a piece of thin metallic foil, a wire passes through the axis of the tube and a potential difference (of the order of several hundred volts) is established between the foil and the wire. If the gas pressure and the potential difference have been properly adjusted, when an ionizing particle traverses the tube it sets off an unstable discharge which is extinguished within a short time. If now two or three of these tubes are connected to a circuit (double or triple coincidence counting circuit) which is so constructed that only when two — or three — counters discharge simultaneously a record is made, then a device is available suitable for the measurement of the intensity of cosmic rays coming from certain directions only, these directions defined by the solid angle enclosed by the common tangents to the counters. The third is a container filled with supersaturated air or gas. When the gas is suddenly expanded the vapor condenses into a fog and the fog particles cluster around ions, thus making the track of an ionizing particle visible. If a magnetic field is set up in the chamber the tracks are curved. From measurements of the curvature one may calculate the energy of the particle producing the track. All these three kinds of apparatus may be coupled to automatic recording instruments to keep a continuous watch on the quantities they are intended to measure.

One of the problems which early interested investigators of cosmic rays was to find out whether their intensity is the same all over the earth, and this brings us to one of the most interesting points in our knowledge of cosmic rays, of decisive importance for the justification of the title of this article. The far reaching implications of this question may be judged by considering that it was originally supposed that cosmic rays were of the nature of light, from which they would differ only in having much shorter wave length — a sort of super-hard gamma ray, as it were. Since the earth is surrounded by a magnetic field which, although relatively weak at its surface, acts for huge distances (of the order of fifty times the earth's radius) it should be expected if cosmic rays were super-hard gamma rays of the enormous energy required to account for their extraordinary penetrating power, they should go undeviated through the earth's magnetic field and consequently their intensity should be the same at all points of the earth. On the other hand, if they were charged particles (for example, electrons) those of least energy should have the greatest difficulty in getting through the magnetic barrier, and consequently the intensity should vary with the location of the observation point on the earth. Physicists then began to emulate astronomers in the role of globe trotters, and expeditions armed with ionization chambers set out to measure the intensity at different points of the earth. It was found,

(*Continued on page 99*)



One of the Carnegie Institute's meters for measuring the intensity of cosmic rays



THE TECH ENGINEERING NEWS

Managing Board

JOSEPH J. DONOVAN, '39
Editor-in-Chief

WILL B. JAMISON, '39
General Manager

PAUL B. M. FARWELL, '39
Business Manager

NORMAN L. LASCHEVER, '40
Associate Editor

EUGENE E. CRAWFORD, '41
Art Editor

SAMUEL P. CARD, '40
Advertising Manager

JACK H. SCHAUM, '40
Associate Editor

JAMES L. BAIRD, '40
Publicity Manager

EUGENE S. WEST, '40
Circulation Manager

JOHN G. LESCHEN, '40
Managing Editor

JAMES S. RUMSEY, '40
Personnel Manager

GORDON A. FAIRBAIRN, '40
Treasurer

Associate Board

H. N. COTTLE, '40
Associate Circulation Manager

LESTER LEES, '40
Contributing Editor

R. DIXON SPEAS, '39
Contributing Editor

Staff

R. W. BLAKE, '41
J. W. FOLLIN, '41
E. H. HUSTVEDT, '41
W. MORTON, '41
J. W. MULLEN, '41

D. D. SCARFF, '41
B. LOESCH, '41
J. VAN RIPER, '41
K. ATWATER, '41
R. A. MARKEY, '41

G. VINEYARD, '41
D. WATSON, '41
T. C. CAMPBELL, '41
C. N. HASERT, '41
L. WILSON, '41

H. J. HEIMER, '41
J. B. MURDOCK, '41
C. L. HALL, '41
W. UNGER, '41
W. J. MEYERS, '41

THE ENGINEERING COLLEGE MAGAZINES ASSOCIATED *Chairman*, PROFESSOR RICHARD W. BECKMAN, Iowa State College, Ames, Iowa

ARKANSAS ENGINEER
COLORADO ENGINEER
CORNELL ENGINEER
ILLINOIS TECHNOGRAPH
IOWA ENGINEER
IOWA TRANSIT
KANSAS ENGINEER
KANSAS STATE ENGINEER
MARQUETTE ENGINEER
MICHIGAN TECHNIC
MINNESOTA TECHNO-LOG
NEBRASKA BLUE PRINT
NEW YORK UNIVERSITY QUADRANGLE
NORTH DAKOTA STATE ENGINEER
OHIO STATE ENGINEER
OREGON STATE TECHNICAL RECORD
PENNSYLVANIA TRIANGLE
PURDUE ENGINEER
ROSE TECHNIC
THE TECH ENGINEERING NEWS
VILLANOVA ENGINEER
WASHINGTON STATE ENGINEER
WAYNE ENGINEER
WISCONSIN ENGINEER

EDITORIALS

PREPARATION FOR MARRIAGE

There are six hundred and seventy-two colleges and universities in the United States, over two hundred of which are now offering some sort of serious program pointed toward a more intelligent approach to marriage. In 1926 there were but twenty-two such programs.

Adding another subject to the curriculum, however, does not guarantee the results hoped for, because not over half the courses now being offered are either forthright or psychologically and physiologically concerned with so fundamental a subject as sex.

In most instances, action by the faculty has resulted from an insistent demand on the part of the student body. There has been opposition of course, but mostly from those of mid-Victorian heritage, who still insist on spelling PURE with the letters F, E, A, and R, or who cling to the myth that marriage is an institution for which we have an inborn, instinctive technique, and so nice people do not discuss it.

But refusal to face a fact makes it none the less a fact. The youth of America are demonstrating their essential mental health by declaring that secrecy has nothing to do with morality or happy married life, and if *good method* is the common denominator of all art and all science, why should it not also be basic in an intelligent approach to establishing a successful home?

This raises two questions that are corollaries to the first: (1) What constitutes good method; and (2) How can it best be taught?

The first question is not susceptible to a simple answer, nor is it likely that, in a field so recently opened to scientific approach, we yet know enough to be sure of much authoritative body of doctrine. But that there are already available approaches far more adequate than the "let your heart be your guide" school, is positively certain.

The second question is also open to more than one interpretation, although it is unlikely that there would be many dissenting voices as to the necessity of a sincere, uninhibited, and reverent mental attitude on the part of the teacher. His attitude will quickly be imitated by the students. Similarly there would probably be general agreement on the necessity of the teacher's having a good deal of rather inclusive experience behind him if what he has to say is to be worthy of serious consideration; and agreement on the value of a multilateral approach to the subject, thus requiring material from competent people in such fields as biology, budgets, child-psychology, humanics, law, medicine — including particularly such questions as prenatal care — sex, and even a sociological understanding of the history and function of the family.

But with these generalities agreement will cease. Some will urge a treatment that is largely theoretical; others will argue that anything isolated from everyday living is sterile and unavailing. Some will hold that such a course should be offered for credit. Others are convinced that instruction in problems having to do with marriage should not only be optional, it should be conducted entirely without written examinations and never for credit. This would mean that those who attended did so from sincere desire, not because they were seeking an easy way to pass off a general study.

The idly curious would come once or twice and then either fall by the wayside or remain to be serious. It would also avoid any guffaws such as "Jones flunked Marriage! Haw! Haw!" or, "Say, did you hear about the quiz on petting?"

In our opinion, the best way to present the subject is through an inclusive series of open general lectures serving largely as background and encouragement to follow up an opportunity for personal conferences, which are in no way related to scholastic standing or credit hours, but very much related to true education. That students will take advantage of such opportunity — sincerely offered — is attested by the fact that in the two weeks following the little "trial balloon" course recently sponsored by the T. C. A., over sixty men consulted with the lecturer, most of them with an attitude amazingly mature.

But whatever one's opinion as to details of pedagogical technique, surely the overwhelming preponderance of student opinion is that Professor Magoun and the T. C. A. have started something they should be allowed to develop further.

MORE FIELD PRACTICE NEEDED

The recent announcement by the chemical engineering course of Technology concerning the opening of a new field station at Parlin, New Jersey, shows the growing consideration given to practical experience in an engineering education. Modern industry demands that a man be equipped with something more than the usual theoretical education when he presents himself for a position. This necessary supplement to college work can be obtained in two ways, either by an "apprenticeship" after the four or five year college course or by a well-planned coöperative course in school.

This latter method of approach can be accomplished in different ways. The electrical engineering course provides positions for students under the direct control of the industry. The chemical engineering course, however, is a strictly educational program, the students remaining under control of the school. With this method of approach, the student has a chance to see all sides of the industry, a thing that would be hard to accomplish in so short a time with a position after school.

Those who do seek the practical knowledge after college, before starting on their career, find that it takes much time without any substantial financial gain. They serve in the lowest positions, rotating from one field of study to another. They have no chance for advancement until they have served in all positions, something that becomes irksome after spending four or five years in college studying what was thought to be an ample preparation for industrial positions.

It is hoped that in the future more of the courses at the Institute will provide an opportunity for industrial practice as an integral part of the course.

FOUR YEAR PLAN IN PRACTICE

Just recently a news report was published to the effect that Germany was calling in all iron work on public property. Civilians were "requested" to donate to the government any iron fences or the like which they might possess. The government very kindly offered the "aid" of the police in the removal of any iron which the people might wish to give. The reasons for this action, as given by the government, were that iron fences were unsightly, medieval monstrosities that might better be supplanted by beautiful hedges. In addition, greater brotherhood among the people might be achieved if these barriers were removed. Ironically enough, all these so called barriers are being torn down only to form an external steel barrier around the country, which will further aggravate the European situation.

There is much significance in this action on the part of Germany. Under the present four year plan, which, by the way, is dealt with in this issue of the TECH ENGINEERING NEWS, there is a statement to the effect that this same iron mentioned in the foregoing paragraph was to be used only as a last resort after all other possibilities had failed. Can this action on the part of Germany mean that she is fighting with her back to the wall? Many leading economists and international commentators feel that this is true. Germany's aggressive attitude forces her to be prepared to fight at a moment's notice and, consequently, to be well stocked with munitions. This calls for a large supply of iron. Germany's economic position is such that she cannot possibly buy any iron on the international market. She has already called on her admittedly last reserve, and it is a question as to where she will turn next. Germany has synthesized a countless number of her necessities, but she cannot synthesize or find a substitute for iron.

That Germany's position becomes worse daily is illustrated by the steady drop in the trade balance since the first of this year. Thus, what seemed to be Germany's only chance of pulling herself out by her boot straps has faded, and the unfavorable trade balance pulls her deeper and deeper into the mire. In view of these events of the past few weeks, it is questionable whether or not the four year plan is successful. What Germany needs more than a four year plan is international good will, which would come as a result of a peaceful attitude accompanied by trade that would put good food into empty stomachs instead of putting power behind one man.

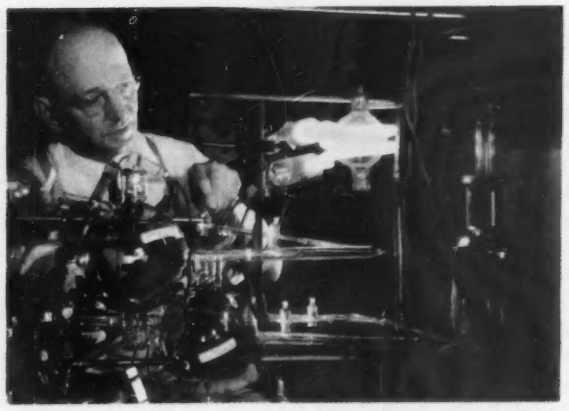
ANNOUNCEMENT

In the last issue of the TECH ENGINEERING NEWS we introduced an innovation in the printing of magazines of this type: the use of the letter-press and the offset printing processes in combination. It was our first attempt to do this and the results were not as good as they might have been. We hope that this issue shows an improvement, and in the future we will do our best to make full use of the flexibility that the combination allows us.

The Managing Board takes pleasure in announcing the following elections — Assistant Editors: R. W. Blake, J. Van Riper, and K. Atwater; Assistant Managing Editors: W. Morton, J. W. Mullen, D. D. Scarff; Assistant Personnel Manager: A. Mengel; Assistant Circulation Managers: W. J. Meyers, B. Loesh, C. L. Hall; Assistant Advertising Managers: H. J. Heimer, J. B. Murdock; Assistant Publicity Managers: T. N. Pook, W. Unger; Assistant Treasurers: L. P. Russe, L. Wilson, C. Trexel, all of the class of 1941.

Courtesy Bethlehem Steel Company

RESEARCH IN REVIEW



©G.E.

COURSE XIX Plasticity of Clay

The properties of ceramic clays, such as plasticity, shrinkage while drying, and strength when dry, are of prime interest to the ceramist. Realizing the practical and theoretical importance of studying the factors influencing these properties, the ceramics laboratory under Prof. F. H. Norton began a systematic investigation two years ago.

There was no possibility of correlating existing data in the literature, since different workers have used such widely different measures of plasticity as penetration of a Vicat needle, flow of a clay-water mixture through a capillary tube, and even water content of the plastic mass. Moreover, the work had been done mainly on ordinary clays with no data being given of geological origin, particle size distribution, type and amount of adsorbed ions, and mineralogical or chemical composition, all of which influence plasticity. At the beginning of the work, a machine was designed which seems to represent industrial clay-forming conditions in its form of test. The machine is of the dynamic type, giving an instantaneous record of the stress-strain relations of a clay bar under torsion. Since that time, the recording system and the type of sample have been materially improved.

Using this machine, Harry Whitlaker studied the effect of particle size on plasticity. By means of a Sharples supercentrifuge, commercial clay was divided into seven practically monodisperse systems. X-ray diffraction patterns proved that the mineralogical composition of all the fractions was the same. The quantitative results showed that a logarithmic relation existed between the measured plasticity and the specific surface as calculated from particle size curves for each fraction.

Kaolinite, the mineral typical of most ceramic clays, is a hydrated aluminum silicate, whose structure consists of a layer type lattice containing some unsaturated outer oxygen ions. In natural clay, these ions are saturated with metallic ions, such as sodium, magnesium, and calcium, from percolating ground waters.

One of the latest theories advanced to explain the stability of clay-water mixtures states that the clay particles come to a position of equilibrium in a double minima potential system. This is caused by the combination of an exponential electrical repulsive force and a Van der Wool type attractive force between colloidal clay particles. Therefore, the stability of a clay paste should be influenced markedly by the type and amount of adsorbed ions, since they control the value of the repulsive potential function. To test this theory, Sidney Speil is studying the effect of the adsorbed ions on the properties of clay-water pastes. By dialyzing each of several monodisperse systems, obtained from the same clay in order to replace the metal ions by hydrogen, and then adding back controlled amounts of metal ions, we should be able to vary the plasticity over a wide range.

To check the uniformity of the different particle size fractions, two machines recently developed in this laboratory are being used. The lack of a simple, convenient method for determining particle size distributions of commercial clays, whose size range is from 100 microns to about 0.05 microns, has been felt for some time. The usual sedimentation methods are not very useful below one micron diameter. While the photomicrographic count method can be used, under ideal conditions, for sizes as low as 0.3 microns, it is very tedious and time-consuming. The supercentrifuge method due to Drs. E. A. Hauser and C. E. Reed of the Chemical Engineering Department uses a machine which is somewhat too strong for the usual ceramic clay. Therefore a centrifuge with a two-foot arm has been made which allows the extension of a simple sedimentation method to a particle size of approximately 0.05 microns by substituting moderate centrifugal fields for gravity. With this machine the particle size of each fraction can be easily checked.

To determine the mineralogical composition, a device is used which automatically records the dehydration behavior of the material being studied. Each clay mineral has a characteristic temperature at which it loses part of the water existing in it in the form of hydroxyl ions. This effect, as well as other changes, makes itself evident by a slight effect which can be detected by a differential thermocouple arrangement. A continuous photographic record can be obtained as the temperature rises from 20 degrees Centigrade to about 1,000 degrees Centigrade. This method gives very precise results, and allows a simple and rapid determination of the mineral type existing in a common clay.

COURSE X Heat Radiation from Gases

Chemical industry has shown a steady trend toward simpler and more direct means of obtaining its products by a more intelligent choice of operating conditions, such as those of temperature and pressure, and by the discovery of suitable catalysts to make the desired reaction take place. As the technique of operating at high pressure has improved and better materials of construction have been developed, more and more chemical processes have exploited high temperature and pressure as a means of making rate or equilibrium conditions more favorable. One of the results of the trend toward operation of chemical equipment at high temperatures has been the increased need for precision in prediction of radiant heat transmission in equip-

ment design, because of the increasing importance of radiation relative to other forms of heat transmission as the temperature level of a system increases. One of the requirements for calculation of heat transfer by radiation is knowledge of the ability of gases to absorb and emit radiant energy, and for a number of years the Department of Chemical Engineering has been at work aiming to supply the necessary data.

Not all gases radiate and absorb in the wave length region of interest, in heat transfer, but among the industrially important gases that do are: carbon dioxide, water vapor, carbon monoxide, sulfur dioxide, ammonia, and the hydrocarbons. The radiant characteristics of the first three of these gases have been investigated, and a Doctor's thesis having as its objective the study of sulfur dioxide, ammonia, and methane is under way.

The measurement of the ability of a gas to emit thermal radiation involves the maintenance of a body of gas having these three characteristics: (1) a known and constant temperature, (2) a definite partial pressure of the radiating constituent and (3) a definite length of path through which the measuring instrument, a radiometer, "sees." The line of sight from the radiometer through the body of gas has as a background different standard radiators or "black" bodies, operating at different temperatures from liquid-air temperature up to 2,400 degrees Fahrenheit. Suitable combinations of readings of the radiometer with the different "black" body backgrounds permit the calculation of both the emission from the gas at its temperature and the absorption by the gas of "black" body radiation of different temperatures.

The most obvious way of confining a column of gas to be studied is by the use of transparent or diathermanous windows, and this is the method used by the physicist in his measurements. Unfortunately, such a method is impractical in the present case, because of the difficulty of choosing a window material that will not only withstand the high temperature but also be transparent to the wide range of wave lengths in the infra-red spectrum. As a consequence, it has been necessary to use a windowless method of confining the gas. This is accomplished by admitting a steady stream of radiating gas into the middle of a chamber, from which it flows in both directions along the line of sight, emerging through refractory nozzles at both ends. Opposing the streams from these nozzles are streams of some non-radiating gas which have just passed through similar nozzles. The plane of impingement of the two streams is sharp, and it is possible to assign a definite length to the body of gas in the central chamber without having any absorbing window material in the line of sight of the radiometer. Apparatus for carrying out this program is now under construction.

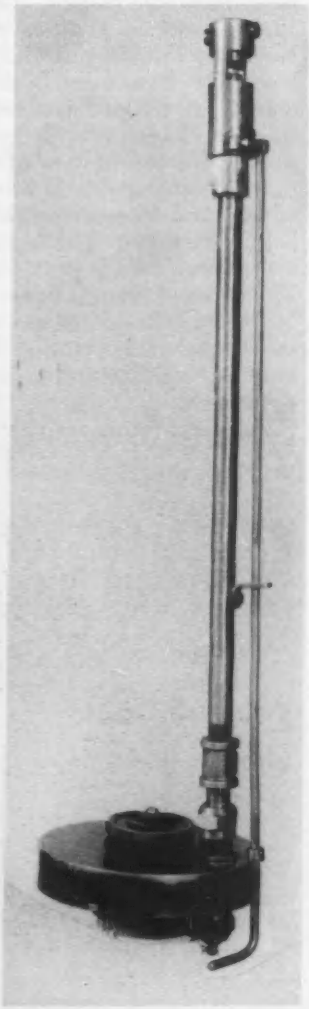
COURSE VII Upper-Air Microbiology

The collection of micro-organisms from the air at various altitudes has interested observers for a considerable time. Pasteur, one of the first workers in this field, made investigations by climbing the Alps to obtain his samples. More recently, the common use of aircraft has enabled various investigators to make collections of micro-organisms occurring in the air at various altitudes in widely separated parts of the world.

Research in the microbiology of the upper air at Massachusetts Institute of Technology was inaugurated in 1932 by Prof. B. E. Proctor in the Department of Biology and Public Health, in coöperation with the Department of Meteorology, which for several years maintained daily flights of the weather ship. During the past five years, airplane collections of micro-organisms and other air-borne materials have been made in the course of more than two hundred separate flights in the vicinity of Boston, some of which were at altitudes of over 20,000 feet. In the United States, among the others who have conducted investigations in this field is Col. Charles A. Lindbergh, who made collections of micro-organisms from the Arctic atmosphere, during some of his exploratory flights in the vicinity of Greenland. The collection of fungus spores above 36,000 feet during the stratosphere balloon flights was conducted by F. C. Meier and L. A. Rogers, of the United States Department of Agriculture.

The collecting equipment used at Massachusetts Institute of Technology has undergone modifications to further the quantitative aspects of the work. The present collector consists of a heavy brass disk containing six holes in which glass collecting slides are mounted in small brass collars. This disk is enclosed in a brass case having inlet and outlet pipes attached, and the disk can be rotated to line up successively each of the collecting slides with the air intake tube. Contamination is prevented by a double protecting collar on the air intake, which is opened when collecting is begun. Air is drawn through the collector at a rate of 1.1 cubic feet per minute by a two-inch Venturi tube, which is mounted on a strut of the plane.

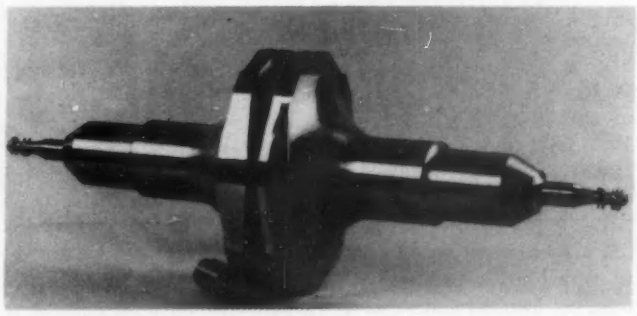
The equipment is prepared for use by oiling both the inside walls of the enclosing case and the disk with a heavy, clear, mineral oil. A similar mineral oil is placed upon the glass collecting slides on the side facing the air intake. The apparatus is then assembled and sterilized by dry heat. The collector is mounted within reach of the pilot and is opened when the plane reaches 1,500 feet. Five samples are taken at successively higher elevations by exposing the various slides to the incoming stream of air so that the material contained in the air adheres to the oiled slides. One slide is not exposed and serves as a control.



The living collected material consists largely of mold spores and bacteria, the greater majority of which may occur naturally in the soil and water. It is one of the aims of this research to study the distribution and viability of fungi which cause plant diseases.

A new, larger collector is being constructed by B. W. Parker of the Massachusetts Institute of Technology Biology Department, which will permit a greater air flow and enable many more samples to be taken. With this equipment, it is hoped to obtain more information on the aerial distribution of dust, molds, bacteria, plant and animal pathogens, and hay fever producing pollens. The accompanying photograph shows assembled collector.

ENGINEERING DIGEST

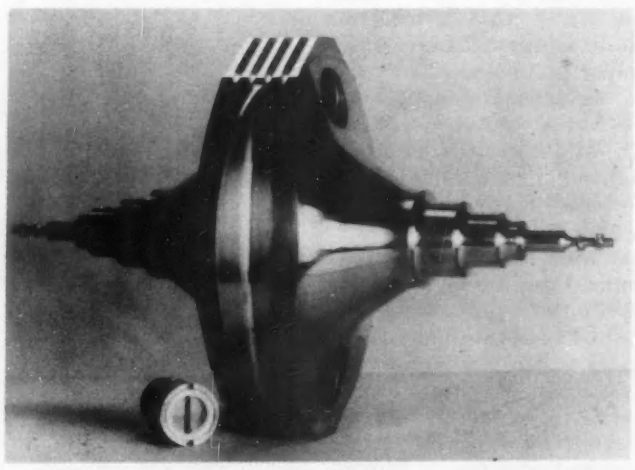


ULTRACENTRIFUGE

Organic cells and tissues are built with colloids and high-molecular substances. Without these building stones life would be impossible. Consequently if the biological and medical sciences are to successfully fight illness and disease they must be able to carefully examine these components of the cells. One of the newer tools that has been devised to aid this study is the ultracentrifuge.

Two standard types of these centrifugal machines have been developed. One produces a field 500 to 15,000 times as great as gravity and the other a field 15,000 to 750,000 times as great as that of gravity. The lower speed machine is driven directly by a high frequency motor and is mounted on ball bearings. The rotation takes place in hydrogen at atmospheric pressure. This machine is used for sedimentation equilibrium measurements in solutions of high-molecular substances and for sedimentation velocity measurements on heavy particles. The high speed machine is driven by oil turbines and is provided with white-metal bearings. The rotor of this machine also spins in hydrogen but at less than atmospheric pressure. It is used for velocity measurements in solutions of high-molecular compounds and for equilibrium measurements on low-molecular substances.

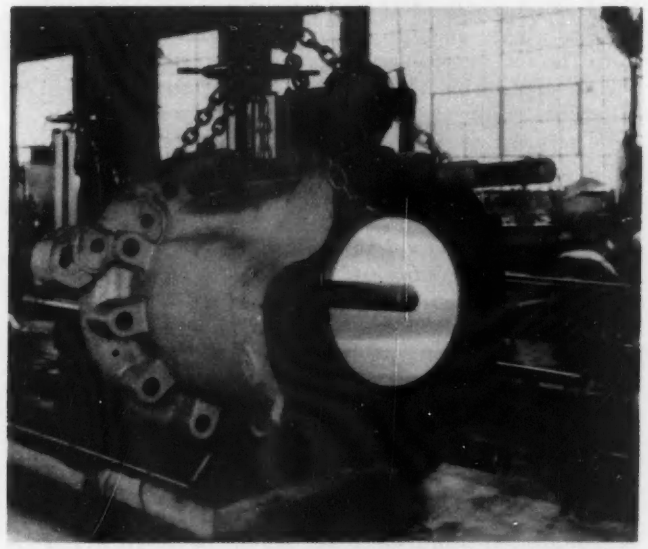
Typical rotors are shown in the accompanying illustration; the upper one is used in producing fields up to 710,000 times the force of gravity and the lower one for fields up to 300,000 times the force of gravity. These rotors are supported by horizontal bearings and kept in rotation by means of two oil turbines, one at each end of the shaft. Hydrogen is kept moving through the unit to maintain a pressure of about 20 mm. Thermocouples in the bearings and a radiation thermocouple near the rotor serve for temperature control. A magnetic generator used in connection with a reed-frequency meter, an oscillograph, or a frequency bridge measures and controls speed.



CYLINDER MAINTENANCE

Cylinder liner wear and maintenance is a particularly important subject today, considering the large number of internal combustion engines in use at the present time.

There are several factors affecting the life and usefulness of cylinder liners and piston rings. The proper design of the piston can increase the efficiency and length of life of the parts. Proper operating conditions and care of the engine are also essential, lubrication probably being the most important single item here.



Courtesy The Petroleum Engineer

Determination of data concerning cylinder wear is made by dry tests; that is, tests using the dry surfaces of metals. The reason for this is the fact that wear never occurs in an engine that has its parts covered with a thin film of oil. Tests have shown that properties of metals such as tensile strength, penetration hardness, etc., do not indicate the wearing qualities of the metal. Thus, "wear" is something that is hard to determine, its cause varying from case to case.

The initial boring or grinding of a cylinder has a great influence upon its final performance. Cylinders that have been ground by an internal grinding wheel and then honed, longitudinally, to prevent the "file effect" of the transverse corrugations show much better wearing qualities than do those merely ground out. In fact, ring wear is often as much as fifty per cent greater

during the "wearing in" period of cylinders finished merely by transverse grinding. This extra wear is due to the rings smoothing off the sides of the cylinder, and the resulting iron dust becoming mixed with the lubricating oil, creating a serious abrasive effect.

Other investigations have shown that certain types of cylinder steel would "work harden" or "glaze" after considerable operation. That is, the cylinder liner and ring would develop wear-resisting films. This effect is especially noticeable with soft, coarse-grained, cast iron. This may be due to the greater graphite content in this type of iron in comparison to the harder, fine-grained, metals.

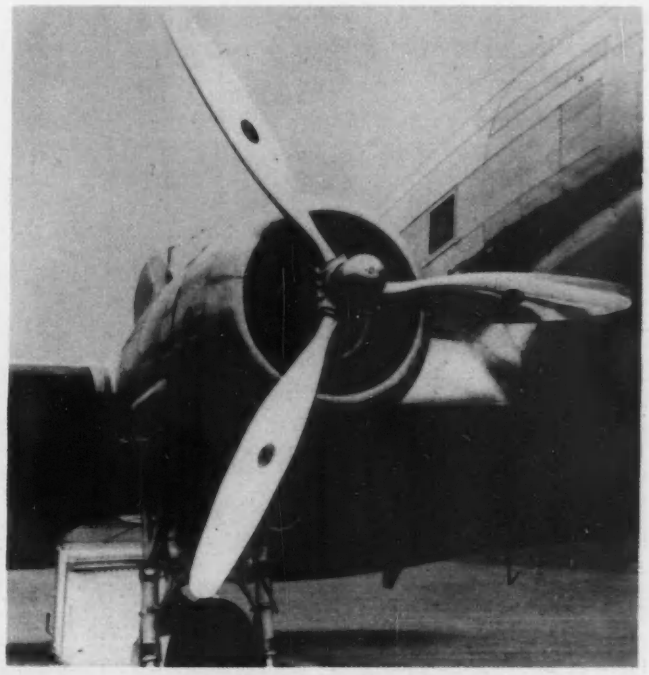
All these factors, however, possibly have little to do with the ultimate long life and efficiency of the cylinder liner and rings. In many cases engines have been operated for years without change of rings and without excessive wear of the cylinder liner. Thus it seems that these mechanical construction factors may not have as much to do with engine life as other factors, such as the range of operating conditions, the amount of care exercised in maintaining a balanced engine, the extent of overheating and overloading, and the cleanliness of fuel and lubricating oil.—*The Petroleum Engineer, February, 1938*

Courtesy Power

ARIZONA SUBWAY

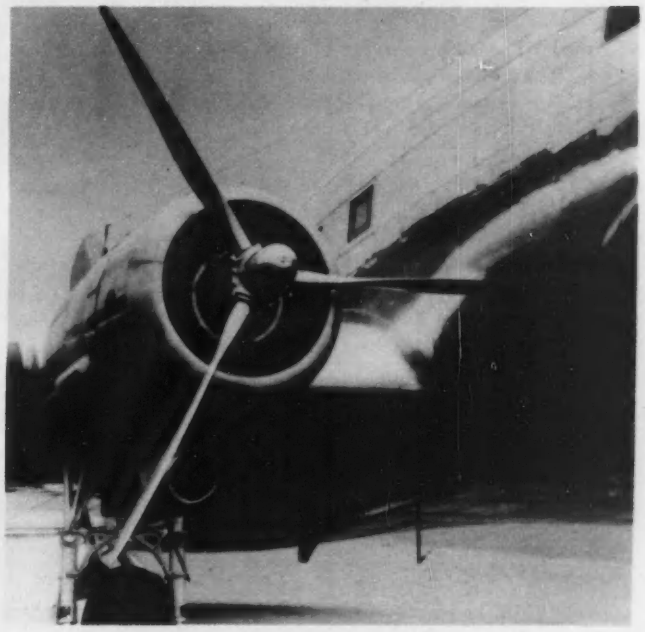
The University of Arizona installed 5,773 feet of service tunnels at its Tucson campus, to conduct steam, water, electric, telephone, and gas lines to more than twenty buildings distributed throughout its grounds. Constructed in 1931, the new tunnel system has successfully and economically overcome severe corrosion and heat loss difficulties encountered because of flood irrigation in the vicinity.

The tunnels, as illustrated in the photograph, are six by four feet in cross section, and are graded away from the central heating plant. The excavations for the tunnels averaged ten feet in depth, and were lined with six-inch unreinforced concrete wall, and covered with a six-inch concrete wall, reinforced with half-inch steel. —*Power.*

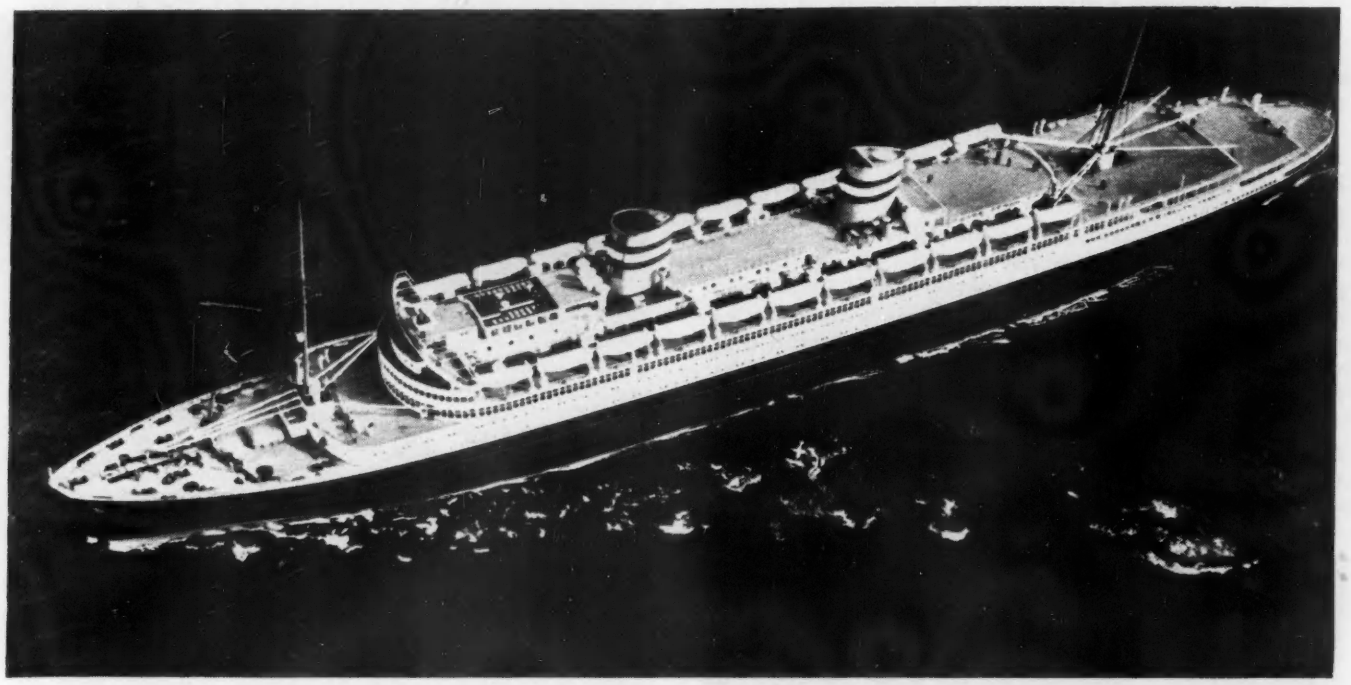


FULL-FEATHERING PROPELLER

The first routine commercial usage of the much discussed full-feathering type of propeller began a few weeks ago. This new hydromatic "feathering" propeller is in reality a constant-speed propeller, with an additional motion which enables it to turn its blades about their axis to a zero angle of attack, as shown below. It thereby functions as an aerodynamic brake on the propeller rotation, and is applied by the air forces encountered during flight. The rotation of a propeller in flight, with its engine not operating, produces a considerable decrease in the speed and maneuverability of an aircraft, and it therefore is undesirable both from the standpoint of economy and safety, and is effectively remedied by the new full-feathering propeller. Within eight seconds, the rotation of a propeller of a multi-motored plane may be completely stoppped by this device, which is shown above in its normal operating position. The hydromatic propeller operates on the same hydraulic principle used in the controllable and constant-speed propellers now in use.



CAREERS OF CARRIER ENGINEERS



On the Great Nieuw Amsterdam— The Largest Air Conditioning System Afloat!

IT WAS no simple task adapting air conditioning to the ocean liner. Carrier engineers worked for years to overcome what seemed to be unsurmountable obstacles. The corrosive effect of salt air and water, for example, made it necessary to introduce special metals for condensers —and drip-proof or water-tight construction for motors. New types of equipment were necessary to meet the restrictions imposed by low ceilings and limited space. Then there were problems of propeller vibration... the rolling of the ship... the rapid changes of outdoor weather conditions. And, above all, the necessity for absolute dependability.

Carrier engineers overcame these obstacles—overcame them so thoroughly that today, any ship built without air conditioning is considered obsolete before she is launched. The "Normandie," the "Queen Mary," the "Mariposa" and dozens of smaller vessels all feature Carrier Air Conditioning for passengers' comfort. And now, with the maiden voyage of the "Nieuw Amsterdam" this spring, the largest air conditioning system afloat will be in operation.

Aboard the "Nieuw Amsterdam," passengers will enjoy true air conditioning at any season of the year. They'll be kept cool in hot weather by Carrier Centrifugal Refrigerating Machines providing 300 tons of cooling—or the equivalent of melting 600,000 pounds of ice each day. In cool weather they'll be warmed by gentle Carrier heating. And always, they'll find perfect ventilation and circulation of clean, humidity-controlled air.

Engineering enabled Carrier to pioneer in the marine field—just as it enabled Carrier to pioneer in every other field of industry and commerce. And the opportunity for still greater engineering, and still greater pioneering are as great or *greater* today than ever before. Youth is no obstacle—at Carrier, recognition is gained by accomplishments, not by age alone. And the young engineer is encouraged to use his abilities to their best advantage—whether they be adapted to experimental, development or installation work in Carrier's world-wide organization.

★ ★ ★

During 1937, Carrier trained 300 recent graduates from leading engineering schools in every section of the country. Carrier needs more men. If you had a good school record, and are interested in the world's most fascinating and fastest-growing industry, write us.

Carrier
Air Conditioning

CARRIER CORPORATION, SYRACUSE, N. Y.

AN ORGANIZATION OF ENGINEERS

PHOTO-ELASTICITY

(*Continued from page 85*)

$$= \frac{\frac{\Delta P}{bh}}{\frac{\Delta \text{ bands}}{h}} = \frac{\Delta P}{b \times \Delta \text{ bands}} = \frac{491}{0.374 \times 15} = 87.7 \text{ pounds per inch per order}$$

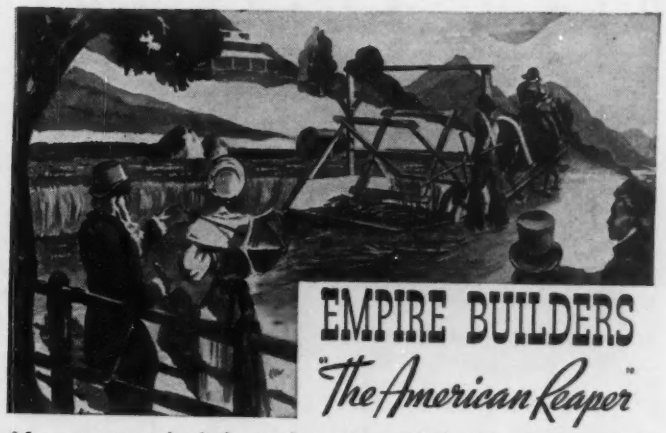
The fringe constant is that number by which one multiplies the order of interference, and into which one divides the thickness (h) in order to compute the difference between the principal stresses at any point. It is necessary, of course, that the fringe constant and the isochromatic lines (s) in the specimen be determined with the same wave length of light. The order of interference at any point in the model can be found by counting the number of isochromatic lines which pass the point during the process of loading.

As an illustration of the usefulness and application of the photo-elastic method, Figure 3 shows the results of a stress analysis along the edge of a cantilever beam of bakelite and the comparison with the theoretical calculation.

The interesting point to note in this case is the concentration of stress caused by the change in section of the supporting end. The more rapid the change in section, the higher will be the concentration of stress, which shows very clearly why it is imperative to use generous fillets in all designs. For the particular case at hand, the ratio of the actual stress determined photo-elastically to the stress computed from the ordinary beam theory is 1.63 or a little over 50 per cent greater. The ordinary beam theory makes no provision for the change of section, so that in cases of this nature where the mathematical theory may not be strictly applicable to all parts, the photo-elastic determination has a tremendous advantage. There are many problems, too, for which there is no mathematical theory, and for these the optical method of stress determination is invaluable.

For a complete determination of the stress at all points in the model, it is necessary to know the individual principal stresses and their directions. The difference at all points can be found from the photographic analysis, and the sum at any point can be found by lateral strain measurement, so that one has a method of separating the two stresses in the interior, and the directions can be found photo-elastically. At

(*Continued on page 98*)



EMPIRE BUILDERS
"The American Reaper"

Many queer mechanical contrivances were devised to take the place of the ancient sickle and crude cradle-scythe, but McCormick's "American Reaper," shown at the Exposition in London's Crystal Palace in 1839, was the only practical machine that survived.

Having already been in business six years before this International Exhibition, R B & W has always continued to contribute to the fast-growing development of American agricultural implements.

Continuously since 1845, R B & W has played an important part in the growth of every major American industry, progressively improving EMPIRE Brand Bolts, Nuts and Rivets to set new high standards of strength, uniformity and accuracy.

R B & W manufacture a complete line of threaded, upset and punched products including various types and finishes of Bolts, Nuts, Rivets, Washers, Screw Pins and Rods. R B & W EMPIRE products are the standard of industry.

Write for free booklet on Bolt, Nut and Rivet design.
Shows standard methods of designation in drafting.
Fits conveniently in drawing instrument case. 8226

RUSSELL, BURDSALL & WARD
BOLT AND NUT COMPANY
PORT CHESTER, N.Y. ROCK FALLS, ILL. CORAOPOLIS, PA.

R B & W

Standard
Instruments
of Precision

C. L. BERGER & SONS
Incorporated
Established 1871
37 Williams Street
BOSTON 19, - MASS.

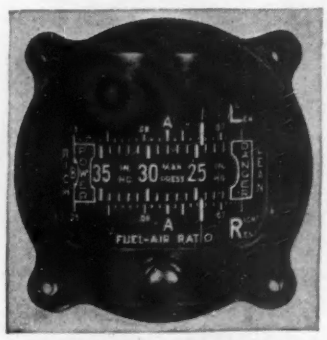
TOUGH, BABIES

Shop all you will, you won't find a drag tape to equal a Lufkin "Hi-way" in durability. But more than that, you won't find a tape as accurate and easy to read.

Made of a special, tough, long wearing steel. Prominent black etched permanent markings. Heavy brass end clips. Leather thongs, detachable. 50 to 300 feet. See your dealer. Write for Catalog No. 12.

NEW YORK 106 Lafayette St
THE LUFKIN RULE CO. SAGINAW, MICHIGAN
Canadian Factory WINDSOR, ONT.
TAPES — RULES — PRECISION TOOLS

high altitude



Dual Indicator for Two-Engine Ship

PERFECT CONTROL OF FUEL-AIR RATIO

Designed as a flight instrument, the Cambridge Aero-Mixture Indicator determines the Fuel-Air Ratio of the engine mixture by analyzing a sample of the exhaust gas. The Indicator, calibrated in Fuel-Air Ratio over a range of from .11 to .065, provides a continuous guide enabling the pilot to control accurately the all-important mixture ratio at sea level or high altitude.

The use of this instrument accordingly makes possible best engine performance under any given set of conditions . . . maximum economy in fuel consumption . . . increase in payload . . . greater safety in that it enables the pilot to fly the maximum length of time when fuel supply is low. . . .

CAMBRIDGE AERO-MIXTURE INDICATOR

CAMBRIDGE INSTRUMENT CO., INC.

3732 Grand Central Terminal **New York City**

BUFF
TRADE MARK TRADE MARK

Superior

Surveying Instruments

Buff & Buff Mfg. Co.

Jamaica Plain, Mass.

Telephone JAMaica 0370

Write For New Catalogue

A Souvenir Plumb Bob sent gratis to Civil Engineers.

PHOTO-ELASTICITY

(*Continued from page 97*)

all points where the directions of the principal stresses are parallel or perpendicular to the plane of polarization of the analyzer, there will appear a dark spot in the image of the model; the loci of such dark spots are called isoclinic lines, and along them the stress directions have a constant inclination with respect to some fixed reference. By rotating the model in its own plane relative to the planes of polarization of the polarizer and analyzer, a series of isoclinic lines can be found and mapped out.

An idea of the accuracy of the photo-elastic method may be gathered from the close agreement between the experimental and theoretical results at a little distance from the changed section in the cantilever beam (see Figure 3). On other problems for which mathematical analysis is applicable, the deviation between theory and experiment has been less than five per cent. Certainly for speed and accuracy in handling problems involving bodies of complicated form, this method has great advantages.

THE GERMAN FOUR YEAR PLAN

(*Continued from page 87*)

picture of what is going on than all tainted news reports.

I think that the Germans have demonstrated one way to get rid of unemployment, namely, by creating things and saving raw materials, but not by destroying things and wasting materials.

Economic planning has some good sides, but it must be combined with the good will of the people as a whole. This being a political affair, all the political rallies which go on over there are full of purpose and are a masterpiece of psychological knowledge of the German soul. Only a person born and reared a German can comprehend that.

Let these people live their own lives; we cannot and should not criticize them violently and spread continuously the seed of hatred as our papers are doing their utmost to do. The German success or failure will depend upon how much politics and business will cooperate — and no one can predict that.

We have our own problems here. The raw-material situation here is absolutely different from that abroad. Therefore the United States must solve its problems in a different way which must be adjusted to the soul and history of our people. But we should look around in the world and try to learn as much as possible from other people's experiments instead of criticizing any and all peoples of the world because they think and live differently than we think and live.

SAMSON SPOT SASH CORD

Trade-Mark Registered U. S. Patent Office

Made of extra quality cotton yarn, carefully inspected, and guaranteed free from all imperfections of braid or finish.
The colored spots are our trade-mark, used only with this quality.
We make braided cord of all sizes, kinds, and colors for all purposes, including sash cord, clothes lines, trolley cord, signal cord, arc lamp cord, and many special cords for special purposes; also cotton twines.

CATALOGUE AND SAMPLES GLADLY SENT ON REQUEST

SAMSON CORDAGE WORKS **89 Broad Street, Boston 9, Mass.**

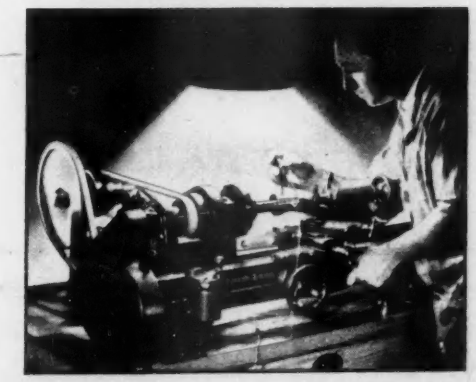
COSMIC RAYS

(*Continued from page 89*)

first by Clay and then by Compton, that the intensity at sea level was least at or near the geomagnetic equator and increased as a regular function of geomagnetic latitude until about fifty degrees, after which it became constant, a fact long denied and finally admitted by Millikan. Thus the existence of charged primary particles was established beyond possibility of doubt, as was also the fact that they come from distances large compared with the earth's radius. In order that an electron, for instance, may arrive at the earth's equator, it must have at least the stupendous energy of about ten billion electron-volts, more than a thousand times greater than the most energetic beta ray known.

The explanation of this latitude effect is simple, and led to the discovery of additional facts which strengthened the conclusion outlined above and shed additional light on the properties of primary particles. In the first place, it was proved that, as a mathematical consequence of a famous theorem due to Liouville, the specific intensity (number of particles per unit area and time) must be the same in all allowed directions at a point of the earth if it is the same along all directions through a point at large distances from the earth. Not all directions, however, are allowed, but all allowed directions fill the interior of a cone of rather complicated shape with vertex at the observer. At a given point of the earth there is a minimum energy for which this cone first begins to open, and the opening increases gradually with the energy, until for a certain energy the cone is completely open and all directions are allowed. Further, for particles of a given energy, the cone opens gradually from low to high latitudes; when it is completely open the intensity obviously cannot increase any more. For positive particles the cone opens up at the western horizon; for negative particles, at the eastern horizon. An important consequence of this is that if measurements of intensity, with double or triple coincidence counters, are made at the same zenith angle, in the east and west azimuths, the intensity should be greater eastwards than westwards if most of the particles are negative, and conversely if positive. The experiment gives greater intensity from

(*Continued on page 100*)



Illustrated above is the New 1938 Model 9" x 3' South Bend WORKSHOP Motor Driven Precision Back Geared Screw Cutting Engine Lathe, price $117., F. O. B. South Bend, Indiana.

More than 39 practical attachments available for this lathe.

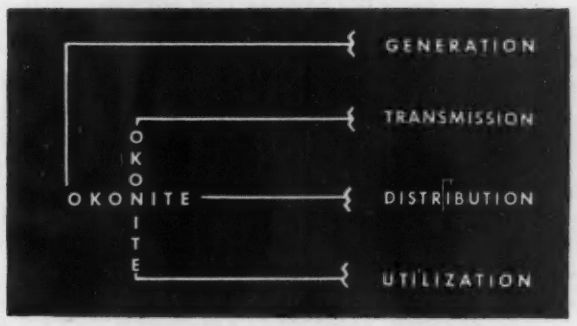
See this and other sizes and models demonstrated at Boston distributors

THE MACKENZIE MACHINERY COMPANY

36 OLIVER STREET, BOSTON, MASS.

Phone Liberty 3525 Open Saturdays until 3 P. M.

THE 4-ϕ ELECTRICAL SYSTEM



Okonite Wires and Cables are designed for every condition of use in each of these phases of any electrical system.

A 220,000-volt transmission cable or the smallest control wire may be the vital link in the chain, and seven laboratories in the Okonite factories provide the testing facilities that insure equivalent strength in each link.

There are many bulletins available on Okonite products that will help in solving problems involving insulated conductors.

THE OKONITE COMPANY

Founded 1878

Executive Office Passaic, New Jersey

As Modern as Tomorrow

Simplex-ANHYDREX deproteinized rubber insulation is a perfect example of the value of research to industry. The Simplex research engineers strove for many years to find a rubber insulation that would not absorb harmful quantities of water.

They finally found it and now all industry can share the results of this research by specifying and buying wires and cables insulated with Simplex-ANHYDREX, the low water absorption insulation made with deproteinized rubber.

It does not need the protection of a lead sheath thus making the completed cable lighter and easier to handle and install.

SIMPLEX WIRE & CABLE CO.

79 Sidney Street, Cambridge, Mass.

COSMIC RAYS

(*Continued from page 99*)

the west than from the east, so that we know that primaries are predominantly positive, and further experiments have indicated that the ratio of positives to negatives is about three to one. Further consequences of the theory, all of which have been checked by experiment, are a change of intensity with azimuth, of which an important particular case is the north-south asymmetry, from which the above ratio of positives to negatives can be inferred, and change of intensity with longitude because the earth's magnetic center does not coincide with its geographic center. From a study of this "longitude effect," it may be deduced that practically all primary cosmic rays are charged.

It was already intimated that the intensity as a function of latitude reaches a constant value beyond a certain latitude. The early explanation of this fact was that the atmosphere acts to absorb all particles of energy below that which just can get through the magnetic field at that latitude. If this were correct, then this critical latitude should depend strongly on the altitude above sea level, since as the thickness of the atmosphere above the observer decreases, so does the absorption. The indications are that such is not the case, and therefore that this explanation must be abandoned. An alternative view is that particles of low energy are prevented from reaching the earth by the sun's permanent magnetic field. Calculation then shows that this hypothesis leads to a value of the sun's field at its surface in excellent agreement with astrophysical observations. Further, there should be a diurnal and a seasonal variation of intensity, the former of which is in agreement with experiment, but there are difficulties which still remain unexplained. If the hypothesis should prove correct, it would show that cosmic ray particles come from distances large compared with the distance from the earth to the sun, and, what is more important for the astrophysicist, cosmic ray measurements provide an independent attack on difficult astrophysical problems. Likewise it has been suggested that, as a consequence of the rotation of our galaxy, there should be a diurnal variation of intensity as a function of sidereal time, the existence of which is as yet uncertain. Thus, the study of cosmic rays may prove of ever increasing importance for astrophysics, and in time may give a clue to the baffling question of their origin, about which too little is known at present.

POWDER METALLURGY

(*Continued from page 83*)

carbide dissolve at the sintering temperature. The solubility decreases with temperature, and cooling of the product to room temperature naturally results in precipitation of the excess tungsten carbide. It is well established, however, that the actual binder is not cobalt metal but a cobalt-rich, solid solution of tungsten carbide. This accounts for the remarkable rigidity and extreme compressive strength of the material, which far transcends that of a mere mechanical mixture of tungsten carbide and cobalt metal.

The process of manufacturing Firthite sintered carbide tips is now complete. In the next installment, the physical properties of the various grades, the design and making of cutting tools, and examples of metal cutting applications will be presented.

(*To be concluded in October* TECH ENGINEERING NEWS)

RADIO

COMPONENTS AND ACCESSORIES
TUBES OF ALL TYPES

Speedy and Courteous Service

New England Distributors for

Aerovox	Mallory-Yaxley
Hammarlund	National
International Resist.	R. C. A.
Thordarson	Jensen Speakers

Presto Recorders and Discs, etc.

Inquiries solicited

H. JAPPE COMPANY
46 Cornhill, Boston, Mass.
LAF. 0510-0511
Worcester, Mass. Dover, N. H.

STEEL

HOT ROLLED COLD ROLLED STRUCTURAL

GENUINE NORWAY IRON

STAHLEKER STEEL CORPORATION
66 BINNEY STREET, KENDALL SQUARE, CAMBRIDGE TELEPHONE TROWBRIDGE 1440

When you want your car serviced by men who know how, coupled with the proper equipment, you will make no mistake in bringing it to us.

For years we have been rendering service to both members of the faculty and students at M. I. T.

Located near by at 306 Massachusetts Avenue.

We have live storage facilities for a limited number of cars for any who are interested.

RYAN & McMATH CO.

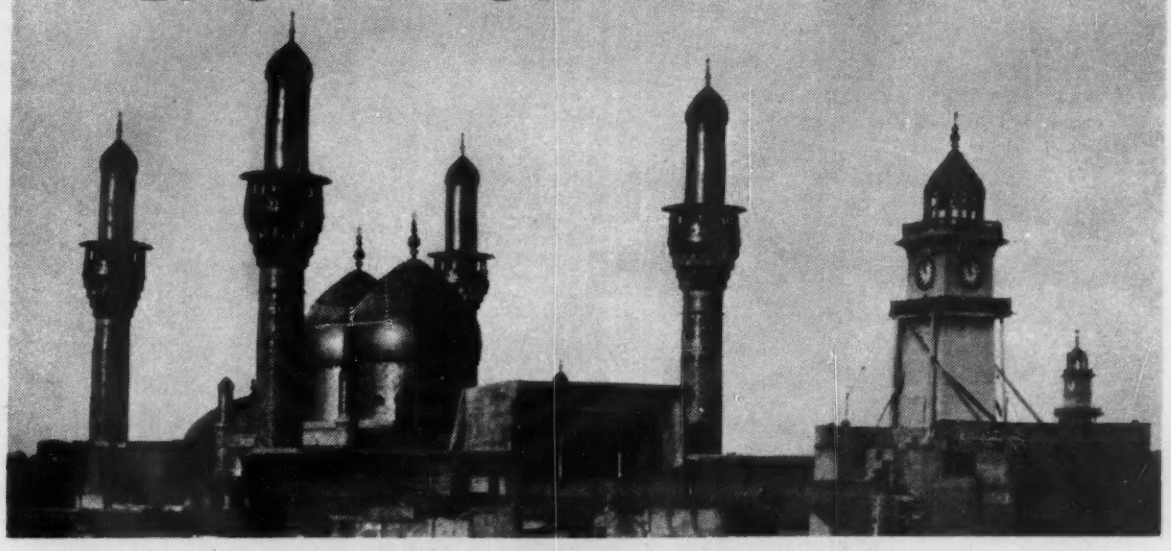
Kirkland 2020 306 MASSACHUSETTS AVENUE

FROM

"BAGDAD ON THE SUBWAY"

TO

BAGDAD ON THE TIGRIS



BY TELEPHONE

"Bagdad on the Subway" (as O. Henry called New York City) is now able to telephone to Bagdad on the Tigris.

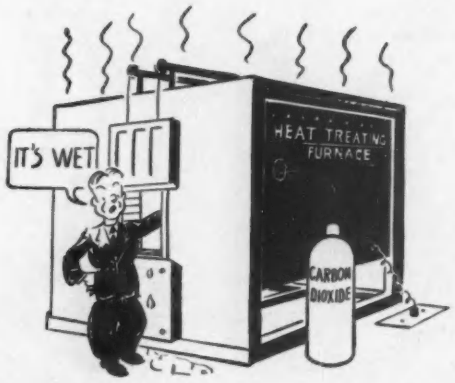
Today your Bell Telephone puts you within easy speaking distance of some 70 foreign countries and a score of ships at sea—93% of all the world's 39,000,000 telephones!

Whether you talk to Bagdad or Bali—to Oslo or Buenos Aires—across the continent or just around the corner, Bell Telephone service proves its value wherever and whenever you use it.

BELL TELEPHONE SYSTEM

Why not call Mother or Dad tonight? Rates to most points are lowest after 7 P. M. and all day Sunday.

G-E *Campus News*



DEW-POINT POTENTIOMETER

DEW on the grass may be fine for the farmers and an indication of fair weather, but it has no place in metal heat-treating furnaces. Moisture in the atmosphere in furnaces causes corrosion on the metal, thus decreasing the size of the part. Because it is impossible to tell the amount of moisture in such a furnace by sticking your hand into it, General Electric engineers have developed a dew-point potentiometer to do this job, and do it accurately.

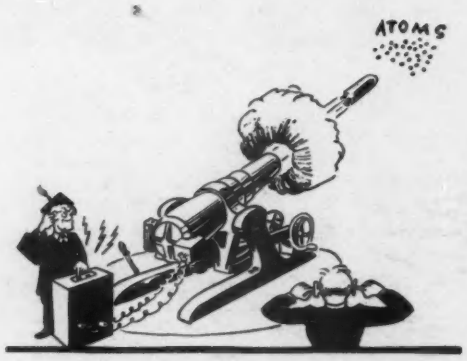
The potentiometer consists of a metallic mirror located in a small chamber into which gas from the furnace is passed and condensed on the mirror. By means of a thermocouple, a balancing circuit, and a direct-reading meter, the weight of water vapor per cubic foot of gas may be derived. Thus the furnace operator can tell if the furnace atmosphere is suitable for the treatment of the metal.

Many of the G-E developmental engineers working on this and similar apparatus are former Test men. The General Electric Test Course augments the theoretical training received by engineering graduates, giving them a practical training in industry.

SPEEDY FLIES

THERE are many legends of nature which have remained for many years, eventually being refuted by naturalists, but one which has persisted up until a few weeks ago is that of the phenomenal speed of the deer botfly. While man plods along at a speed of 400 miles per hour in his airplane, one entomologist calculated the speed of the deer botfly to be 800 miles per hour. Digressing from his usual type of experiments, Dr. Irving Langmuir, Nobel Prize winner in the General Electric Research Laboratory, exploded this entomological myth by means of a series of tests.

Using a piece of solder the size and shape of a deer botfly, Dr. Langmuir showed that if this insect traveled at 800 miles per hour it would encounter a wind pressure of 8 pounds per square inch—enough to crush it, and that maintaining such a velocity would require a power consumption of one-half horsepower—a good deal for a fly. He also demonstrated that the insect would be invisible at speeds in excess of 60 miles per hour, yet the entomologist estimated the speed of the fly at 400 yards per second because he saw a brown blur pass by his eyes. Finally the calculations showed that if the fly, while traveling at this speed, struck a human being, it would penetrate the skin with a force of four tons per square inch and bury itself deep in the flesh.



BOMBARDING ATOMS

The modern miracles of aviation, television, and World's Fairs are taken quite calmly in this twentieth century of progress. But it is a different matter when scientists start snapping the whip with ions to smash ultramicroscopic particles called atoms into even more minute portions. And that's just what scientists are doing over at Harvard University.

Using a machine called a cyclotron, devised by Prof. Lawrence of the University of California, the Harvard physicists are bombarding atoms by accelerating ions to a tremendous speed and shooting them out through a hole in the side of the machine. But people are talking about this barrage of ionic ammunition because the results have proven successful in the treatment of cancer.

This is the third of such atom-smashing machines for which the General Electric Company has furnished parts. Even in such academic and highly specialized fields, Test men are called upon to make their contributions.

GENERAL ELECTRIC

90-58DH

The Murray Printing Company
Kendall Square, Cambridge